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Design of a Gene Technology Teacher Aid: An Interactive Electronic Utility

Benjamin A. Mohlenhoff
Worcester Polytechnic Institute

Elisabeth A. Kast
Worcester Polytechnic Institute

Megan E. Williamson
Worcester Polytechnic Institute

Sarah E. Pavis
Worcester Polytechnic Institute

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Design of a Gene Technology Teacher Aid: An Interactive Electronic Utility



CSIRO

An Interactive Qualifying Project Report
submitted to CSIRO Education and the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

Elisabeth Janiszewski

Benjamin Mohlenhoff

Sarah Pavis

Megan Williamson

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Approved:

Professor Chrysanthe Demetry, Major Advisor

Professor Edward A. Clancy, Co-Advisor

Abstract

This project describes the development and implementation of a framework for an electronic unit of teacher materials for Commonwealth Scientific and Industrial Research Organisation (CSIRO) Education Victoria. The electronic unit complements CSIRO Education Victoria's Gene Technology workshop, aimed at secondary school students in years 9 and 10. The unit contains articles, multimedia and activities which we created pertaining to various topics in Gene Technology. The unit was created in HTML webpage format and then transferred to a CD-ROM for distribution.

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Table of Acronyms

AEI – Australian Education International

CD-ROM – Compact Disk - Read Only Memory

CSFII – Curriculum Standards Framework II

CSIRO – The Commonwealth Scientific and Industrial Research Organisation

DNA – DeoxyriboNucleic Acid

EBONI – Electronic Books ON-screen Interface

HTML – HyperText Markup Language

IQP – Interactive Qualifying Project

KLA – Key Learning Area

SEC – Science Education Centre

VCAA – Victoria Curriculum and Assessment Authority

VELS – Victorian Essential Learning Standards

WPI – Worcester Polytechnic Institute

Executive Summary

Teachers and educational professionals within Australia are observing a drop in student interest in the subject of science. In response, the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Education division has created an educational outreach program in order to present scientific topics in accordance with state and national curricula in such a way that the material is both attractive and thought-provoking to students. Currently, CSIRO Education within the state of Victoria conducts ninety-minute workshops in Australian classrooms on a variety of scientific subjects, such as forensic science, chemistry, physics, and genetic technology. These workshops are believed to be effective in creating at least short-term student interest in the material presented, but as the workshops themselves are only ninety minutes in duration, CSIRO Education Victoria believes that providing more in-depth information about each topic to Victorian teachers would allow teachers to maintain a higher level of student interest in the scientific material over a longer period of time. Such information would assist teachers to easily perform follow up lessons related to the workshops.

A project commissioned by CSIRO Education Victoria in 2004 examined the possibility of providing more in-depth materials and concluded that there was enough teacher interest to warrant the creation of educational units containing additional information regarding each workshop topic. The project also concluded that the format most desired by Victorian teachers to distribute this information was that of an interactive website (Adams, Doherty, and Smith, 2004.)

The goal of our project was to design and create an electronic learning unit consisting of teacher support materials that supplement CSIRO Education Victoria's Gene Technology workshop. These materials will be electronically delivered to teachers in the form of an interactive website distributed on a CD-ROM. The educational content of the unit complements and expands on the information taught within CSIRO Education Victoria's Gene Technology workshop and is intended to augment both teacher knowledge and student learning about genetic technology and related topics. Before starting to design such a unit, we researched styles of teaching, student learning styles, and guidelines for creating websites for educational materials and other such digital units currently available to teachers. We then created our own unit utilising CSIRO Education staff and school teacher input to supplement our research. After creating the unit, we had CSIRO staff and teachers review it and filled out surveys to assist in our assessment of the product. We then drew conclusions about the unit and made recommendations for future improvements and testing. Our completed project can be broken into two main pieces: a general framework used in the design of an educational unit and the complete Gene Technology electronic unit.

Framework Design

The framework was developed by studying teacher preferences, reviewing similar lesson plans and kits from museums and other science education centres and conducting research on how best to create informational websites and electronic books. The framework is a collection of rules, design guidelines, and templates which are intended to enable CSIRO Education Victoria staff to generate effective, easily-distributable, and aesthetically appealing educational units in the form of interactive websites. The framework is topic-independent and can therefore be used to generate educational units for any of the plethora of workshop topics that CSIRO Education Victoria offers. The framework allows for the generation of an educational unit without needing to be concerned with the technical details and physical structure of the unit. The main task when using this framework to implement a unit will be the generation of the educational content.

Gene Technology Unit

The second component of our product is the content within the Gene Technology educational unit. This educational content was generated while considering several factors. Due to the ever-evolving nature of science, teachers sometimes feel uncomfortable teaching cutting-edge subjects such as genetic technology when they may not have a firm grasp of the subject. In addition, due to the constant discoveries of new information on such topics as genetic technology, teachers' knowledge can become outdated and incorrect. Therefore, the educational content within our Gene Technology unit provides a significant amount of background information to teachers so that they will become better acquainted with the subject of genetic technology. The content of the unit is organised as a series of articles that assume little to no prior knowledge. By supplying teachers with clear, concise, and informative writings on a particular topic, teachers will feel more confident when teaching the unfamiliar material to students.

The Gene Technology unit content encourages student knowledge and interest in the field of genetic technology. The educational unit content includes various types of activities for teachers to use with students, such as small group projects, large group discussion, handouts, and scientific experiments. Research indicated that activities such as these can engage the students, stimulating thoughtful discussion of genetic technology and helping them to gain a hands-on understanding of the subject. The educational unit content also includes both static (for instance, images) and interactive (such as Macromedia Flash movies) media to provide teachers with useful learning aids that present concepts to students. The educational unit content was created to provide teachers with all the necessary materials to conduct a number of classes on genetic

technology in order to extend the impact of CSIRO Education Victoria's Gene Technology workshop.

Conclusions and Recommendations

This project also includes conclusions and recommendations to CSIRO Education Victoria regarding how to improve the quality of the unit. Data were collected from two separate groups: CSIRO Education Victoria staff and Victorian teachers who have experienced the Gene Technology workshop. Both groups were asked to provide feedback on the format of the unit, the level of relevance of the different topics, and the applicability of the activities and media provided. We analysed the information obtained from the CSIRO Education staff and teachers to reach conclusions on the effectiveness of the unit and to outline improvements needed for the unit to increase the value of the unit as an extension to CSIRO Education Victoria's Gene Technology workshop.

Based on the assessment data, we have concluded that the Gene Technology electronic unit appeals to teachers and CSIRO Education Victoria staff. We also have concluded that the framework produces a viable electronic unit that is easy to navigate and understand. Because of the positive responses of teachers and CSIRO Education Victoria staff, we recommend that CSIRO continue to refine the Gene Technology unit, as well as implement additional units using this framework.

1 Introduction

Scientific research plays an important role in any modern society, affecting a myriad of areas such as medicine, transportation, and agriculture. As scientific knowledge increases, more areas in need of research are identified. In order to pursue these additional research areas, both new ideas and new scientists must be in constant supply and therefore an educational system which promotes the development of scientists is desirable. When students are exposed to interesting and informative science education, they are more likely to pursue that scientific interest.

In Australia, technological and scientific innovation continues to advance. However, it is evident throughout all levels of the Australian educational system that student interest in scientific subjects is waning. Such disinterest in science is an unfavourable situation for Australian society, as a lack of student scientific interest may result in fewer scientists in the future. In order to continue furthering scientific and technological advances, educational practices need to be revamped, such that more student interest in the subject of science is generated. According to Dr Kath Kovac, editor of a leading scientific magazine, "Students need to feel that science is exciting and relevant to them. Teachers also need to keep pace with new discoveries to keep science classes interesting." (Helix, 2004.) Developing new lesson plans that address these concerns may generate more student interest in the subject of science.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the national research agency of Australia. CSIRO's primary goal is to develop technological and scientific innovations through scientific research. As a research organisation, CSIRO supports the enrichment of science education by providing various educational services to Australian schools. CSIRO Education's goals are to illustrate how its scientific research directly benefits Australian society, to generate student and teacher interest in the science fields, and to encourage students to take up careers within the fields of science, engineering, and technology. The Organisation recognizes that cultivating an interest in science within students is as essential as teaching them scientific content. To that end, CSIRO commissioned Science Education Centres (SECs) throughout Australia, its bases for educational outreach. The educational officers employed at the Centres carry out the educational mission of CSIRO by conducting interactive workshops throughout various disciplines of science.

The workshops currently are well received. They communicate as much scientific knowledge to students as is feasible in each of the specific topics covered. The workshops last for approximately ninety minutes, covering pertinent background information and typically incorporating a hands-on activity as well as full class discussions. At the conclusion of each workshop, a basic set of educational materials is

distributed to teachers. Currently, these materials contain only information about what was covered within the workshop. Because of the limitations of time, the benefits of the workshop are short-lived and the material is often forgotten quickly after the workshop ends if teachers do not incorporate the material into their teaching. CSIRO Education Victoria hopes that by providing teachers with more comprehensive post-workshop materials, the workshop material may be expanded upon in the classroom.

In 2004, CSIRO Education Victoria commissioned a project to study the levels of teacher desire for such post-workshop materials. After conducting surveys and focus groups with both students and teachers, the study concluded that there was significant interest in an electronic, interactive extension to CSIRO Education Victoria's current programs. (Adams, Doherty, and Smith, 2004.) The study also concluded that the preferred delivery method of the post-materials was either through an interactive website or through a CD-ROM.

To assist CSIRO Education Victoria in their efforts of increasing student interest in the sciences, we produced a framework that outlines a format for producing effective post-workshop materials and implemented this framework, creating a complete electronic unit. We researched teaching and learning styles, as well as development and design of educational websites to develop the framework. We then implemented the framework, producing the post-workshop materials for the Gene Technology workshop. Using feedback from both CSIRO Education Victoria staff and from teachers who observed the workshops, we continued to refine our design. Our final product, a comprehensive CD-ROM containing teacher materials and student activities relating to the Gene Technology workshop, was delivered to CSIRO Education Victoria, along with recommendations for improvement and expansion.

2 Background Research

Topics relevant to the creation of an electronic education unit for science teachers were the primary focus of our literature review. Research into the Australian school system provided us with an understanding of the context in which our educational unit was employed. Information on our sponsor, the Commonwealth Scientific and Industrial Research Organisation and how they are involved in the education system was also examined. Teaching styles and materials employed by science teachers were studied, as well as different ways that student knowledge could be assessed. Guidelines for the development of electronic resources, such as e-books or interactive websites were also studied. It was also important to examine lesson plans that are currently available for science teachers to use in the classroom.

2.1 The Australian Education System

The Australian education system lasts thirteen years. There is a single year of preparatory schooling (non-compulsory), six or seven years of primary education, and five or six years of secondary education. Examining the levels of funding and technology within Australian schools helped us to determine the feasibility of incorporating electronic learning materials into their classrooms. In addition, studying the current curriculum standards was critical in determining the content to be included within an electronic unit.

2.1.1 Funding and Use of Technology in Australian Schools

There are three main types of schools in Australia: governmental, Catholic, and independent. Approximately one-third of Australia's 3.3 million students attend a private school of some kind, resulting in a ratio that Anderson (1993) claimed is "proportionally higher than any Anglo-American country and [is] growing." (as cited in Potts, 1997) This ratio contrasts greatly with the approximately ten percent of students attending private institutions in both America and England. (Bone, 1996) (as cited in Potts, 1997)

Australia also differs from other nations such as the United States in that both public and private schools receive funding from the federal government. In America, private schools are funded mainly through alumni donations and a mandatory tuition, whereas public schools are funded through an educational tax collected from the inhabitants of each school district. The federal or state government may contribute funding as well. The amount of funding available influences the level of technological integration within a school. Funding is an issue central to our project, because schools with a greater amount of available funding will be more likely to utilize programs such as CSIRO workshops.

The prevalence of technology available in an Australian classroom varies greatly across each state of Australia, as Andrew Trotter (2004) explained in an article for Education Week on the Web. Trotter stated that "...Australia's population has easily adopted the Internet, cell phones, and other communications technologies" (Trotter, 2004) and as a result various technologies are becoming prevalent throughout Australian schools. However, funding levels provided to schools by the government are not constant and can vary from state to state. The amount of technology available in an average Victorian classroom is greater than the amount found in an average classroom in Queensland (Trotter, 2004.) Also, there are often differences in federal or state funding provided between public and private schools. Since private schools most often rely on wealthy non-governmental sources of income, they generally feature a better-developed technology program. During the middle of the 1990's, many private schools began to require that each student have a laptop. Trotter states that, "...the private schools made fertile ground for laptop initiatives. Many of the schools have required parents to purchase laptops for their children, much like pencils and composition books." (Trotter, 2004) Trotter goes on to mention that after private schools began to require laptops, public schools began to increase their efforts to integrate technology into their classrooms as well, in an effort to keep pace with the private schools.

2.1.2 Curriculum Standards in Victoria

While schools vary in the amount of funding and technology available, all follow the same curriculum standards provided by the government. Australia has a division of labour between the State and Federal governments regarding education. As stated on the website of Australian Education International (2005), the federal government of Australia primarily deals with national educational policies and mandates. The Australian government also dictates a standard curriculum that each individual state is responsible for adhering to. The federal government provides funding to each state while the states in turn ensure that the federal curriculum is followed. States may set up curriculum standards of their own to supplement those provided by the federal government.

The Victoria Curriculum and Assessment Authority (VCAA) is the agency that sets the standards for learning in the state of Victoria. There are two main guidelines for the curriculum: the Curriculum Standards Framework II (CSF II) and the Victorian Essential Learning Standards (VELS). The CSF II is currently used in the Victorian school system. However, the VELS is in its preliminary evaluation year and is planned to become compulsory statewide during the next school year, replacing the CSF II. Both frameworks are broken down into six levels based on school year and within each level are a variety of disciplines and skill sets that are required.

The Curriculum Standards Framework II (CSF II) outlines eight Key Learning Areas (KLAs): The Arts, English [or English as a Second Language], Health and Physical Education, Languages Other Than English, Maths, Science, Technology, and Studies of Society and Environment. The Science KLA for Level 6 is broken into

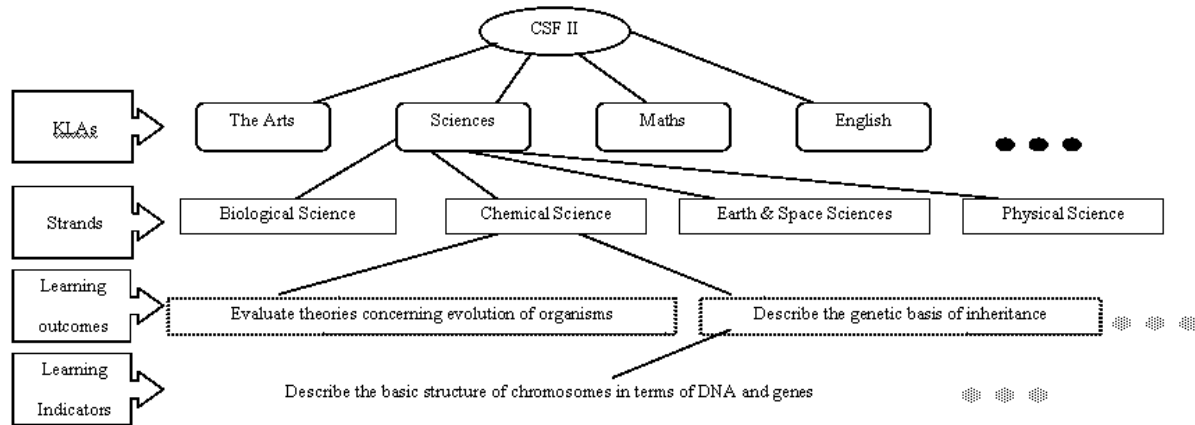


Figure 1 - CSF II Structure

four areas: Biological Science, Earth and Space Science, Chemical Science, and Physical Science. Within the Biological Sciences, there are five learning outcomes, which are specific topics students must understand before the completion of year 10. The most relevant outcome to Gene Technology is learning outcome 6.5, which requires that pupils have an understanding of genetics and inheritance. Each learning outcome has indicators, which are concepts that the students must be able to explain in order to be considered competent in that particular area of study. Within the genetic learning outcome, there are five indicators. The most relevant and important indicator to our project is that students must be able to explain the relationship between genes, DNA, and chromosomes and also discuss human uses of genetic knowledge. Figure 1 illustrates the general flow of the CSF II guidelines.

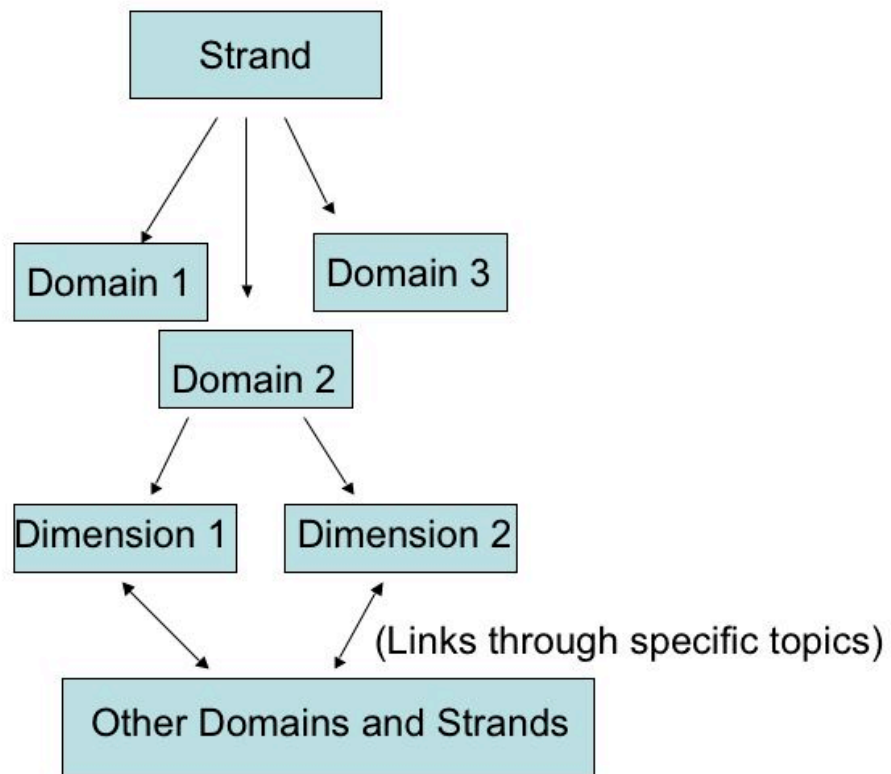


Figure 2 - The Victorian Essential Learning Standards (VELS)

The second curriculum set, the Victorian Essential Learning Standards, illustrates alternate curriculum guidelines. The conceptual model of VELS is that of a rope with three strands: Physical, Personal, and Social Learning which focuses on personal health and interpersonal development; Discipline-based Learning, which focuses on facts and theories; and Interdisciplinary Learning, which focuses on critical thinking, technology, and creativity. The conceptual model of a rope effectively describes how intertwined each strand is with its two neighbors, as each strand relies and draws rather heavily upon material found within each of the other strands. Within each strand, there are a number of domains. The term “domain” is defined within the VELS as a “distinct but interrelated [area] of knowledge, skills and behaviours considered essential in the education and development of students” (<http://vels.vcaa.vic.edu.au/about/glossary.html>, 2005). Figure 2 shows a breakdown of one of the sections of the VELS.

Within the Discipline-Based Learning strand exists the Science domain, which contains two dimensions. The first dimension focuses on student knowledge of scientific concepts. This dimension is mainly fact-based; however, the final goal is an overall understanding of how science, human beings, and the environment work together. The second dimension of the domain involves comprehension of the application of science to

human problems and how human beings work with science. By the end of Year 10 of their schooling, students are expected to be independent, scientific thinkers. They should be able to critique scientific methodology and discuss ethical issues that come up in the media. Students study the multidisciplinary applications of science, such as biotechnology and communication technology and learn about the theories that carry across all scientific fields. The focus in this level is on connections between various fields of science and their application to society and the environment. How science relates to society is a far more practical dimension of science than mere comprehension of content (VCAA, 2005.)

Gene technology can also partially fulfill the Interdisciplinary Learning strand in the VELS. The Design, Creativity and Technology domain demands that students design and evaluate processes and the laboratory techniques found throughout Gene Technology may be applicable to this domain. Similarly, when students can effectively debate the controversial issues of ethics related to genetic engineering, cloning, or similar topics, they will be fulfilling part of the domain of Thinking, which can be found within the Interdisciplinary strand. Because of the multi-faceted nature of Gene Technology, the topic can be discussed and applied to a number of the VELS in a variety of domains.

2.2 The Commonwealth Scientific and Industrial Research Organisation

To assist in the creation of any project, it is important to gain some understanding of the group for whom it is being made in addition to those who will be using it. CSIRO is a governmental organization that receives funding from the Australian government in order to pursue research that benefits Australian society as a whole (personal contact, Mr. Chris Krishna-Pillay, 2005). (For information regarding the history and current composition of CSIRO, please see Appendix A.) The educational sector of CSIRO also receives funding from private donations.

2.2.1 Current CSIRO Educational Programs

CSIRO currently offers many programs throughout Australia for school-aged children. The Organisation brings its knowledge and experience in various disciplines of scientific and industrial research to design and implement educational programs for Australian children. Education and outreach are two of the main goals of CSIRO and they strive to implement and maintain effective programs that children will find intellectually stimulating. CSIRO feels that educating today's youth about science is an important step towards increasing the number of scientists and researchers in Australia's workforce.

CSIRO maintains nine Science Education Centres (SECs), one in each state's capital city in Australia. These Centres are laboratories where students and teachers can go to witness CSIRO's various scientific programs and demonstrations. Also, each

Centre maintains a traveling component called the “Lab on Legs” which allows students to participate in CSIRO programs if schools are not willing or able to travel to their state’s Science Education Centre. The “Lab on Legs” program sends CSIRO Education staff to schools to present workshops to students in their classrooms.

Currently, CSIRO programs feature a broad spectrum of science topics, for all grade levels. The available programs vary somewhat from state to state. The Science Education Centre in Victoria offers programs including: Air and Weather, Electricity and Magnetism, Energy and Its Uses, Forensic Frenzy, Gene Technology, and Electronics. (CSIRO Organisation, 2005) All of these programs are offered as a combination of “hands on” demonstrations, where the students participate in the experiments and thus gain first-hand knowledge of what is discussed, as well as a demonstration by the presenter, allowing significantly more complex material to be displayed.

2.2.2 CSIRO Education Victoria’s “Gene Technology” Workshop

The Gene Technology workshop is a program created to educate the participants about various experimental techniques and equipment used throughout the fields of genetics, biochemistry, and forensic science. Various ethical issues regarding gene technology, such as cloning, are also introduced to the workshop participants. The techniques that are covered within a Gene Technology workshop include gel electrophoresis and DNA extraction. Workshop participants are also instructed in the usage of a micropipette, a tool that is used to measure and siphon minute amounts of fluid. In addition, the usage and inner workings of a centrifuge are explained.

A Gene Technology workshop is approximately ninety minutes long. However, the length of any particular workshop is subject to change based on how the session fits into the school schedule. Presentations rarely last less than seventy minutes or last longer than ninety minutes. The workshop begins with the presenter introducing himself and CSIRO. Then, the presenter gives an explanation of DNA and why its discovery ranks among one of the most important scientific discoveries in the history of mankind. References to popular culture in the form of the American television program “CSI: Crime Scene Investigation” are often utilized by the presenter when conveying the importance of DNA to the workshop participants.

The discussion on how our knowledge of DNA is used segues well into the next segment of the workshop; a hypothetical scenario is set up where trace amounts of blood from an unknown source have been discovered on the shirt of a murder victim. The presenter then explains that DNA from blood of the victim and suspects has been extracted and needs to be analysed. The presenter utilizes a process known as gel electrophoresis to analyse the samples. Micropipettes are distributed to the participants and their usage within gel electrophoresis is explained. Then, the participants disperse to

lab stations that have been set up around the room where they learn to use the micropipettes for about three minutes. At this point in the workshop, student volunteers go to the front of the class and use the micropipettes to insert eight micro liters of DNA into the electrophoresis gel. Electrical current is applied to the gel and the presenter explains how electrophoresis works and why it is used.

The presenter then begins to explain the next segment of the workshop, DNA extraction. During this segment, participants receive a vial of pulverized wheat germ from the presenter and are told that they will be extracting DNA from the wheat germ. The wheat germ substance has already been prepared and is in a liquid state, which helps to save time. The vials are first placed into a centrifuge for several minutes and the heavier pieces of the cell collect at the bottom of the vial, forming what is known as a pellet of cellular structures. After several minutes, the vials are removed from the centrifuges and the supernatant within the vial, which contains the lighter cellular structures and the cytoplasm of the cell and is resting on top of the pellet, is poured off and disposed of into a sink. A detergent is introduced into the vial, the pellet is re-suspended and the entire mixture is placed back into the centrifuge for a few minutes. The nuclei are broken apart by the detergent, so the contents of the nuclei, most importantly the DNA, float to the top of the tube. Ethanol is then poured gently into the top layer of the vial, causing the DNA to precipitate and form long strands, which one can manipulate with a wooden stick.

By the time this segment is complete, the electrophoresis machine has completed its task of moving the pieces of DNA through the gel, is turned off, and the gel is stained in order to make the pieces of DNA easier to see. While the gel is being stained, the presenter begins a discussion about various ethical issues within the realm of gene technology, such as cloning, the governmental regulations of gene technology, and stem cell research. Safety is stressed throughout the workshop, especially when the usage of a centrifuge is explained. The electrophoresis setup can be dangerous as well, as a rather large current is running through the gel for approximately half of the workshop. Ethanol and the detergent used in the DNA extraction segment are not particularly dangerous, so no specific precautions need to be taken.

2.3 Science Education and Learning

The CSIRO workshops involve a “hands on” activity requiring active student participation. Our research indicates that students who are more engaged in learning are likely to enjoy the work they are doing. Thus, this section outlines science education in secondary schools, interactive media, and learning styles.

2.3.1 Science Education in Secondary Schools

The teaching style used in a classroom is believed to have an effect on how confident students are with their understanding of the material being taught. It is believed that most schools teach using a closed teaching style (Walton, 1997). In this setting, students are passive participants in education. The material is presented in a lecture format and there is often little time to discuss issues not specified within a prescribed curriculum. Teachers must cover the standards dictated, instead of having the freedom to focus on topics and examples of their own choosing. Students are all expected to learn at the same pace, in the same manner. These curricula often omit real-life scenarios in their science teaching and instead focus on many abstract concepts which do not, typically, generate an interest in science (Nair, Majitech, 1995.)

However, as a result of the advent of newer teaching styles, students are now being given the opportunity for a more open learning style. Education centres such as those maintained by CSIRO utilize this open learning style. There is less structure to the curriculum, so students have the ability to focus on what interests them (Harrison and Mannion, 1997). In such an informal setting, students become more motivated and there is increased opportunity for self-learning. Walton notes that, “attitudes of school pupils towards science seem to benefit from being exposed to informal learning situations” (1997, p. 3) and that a positive attitude towards the sciences, often generated in an informal setting, will correlate to a better attitude inside the traditional classroom.

Each teacher brings his or her own personality to the classroom, which can greatly affect the students’ learning. Looking at two different case studies illustrated some of the different methods science teachers with different backgrounds employ to educate their students. One case study, done by Lemberger et al (1998), followed three new secondary school science teachers and described their teaching methods. Another case study, done by Southerland et al (2002), examined three science educators teaching upper secondary through first year university students, who each had a strong science background as they taught a new, reformed curriculum.

The most striking difference between the two groups was the variation in general beliefs about science. The young teachers, whose science background only included the courses covered in their education program, had a positivist attitude towards science (Lemberger et al, 1998). They believed that science knowledge was fixed and that the laws could not change. Conversely, the science educators in the Southerland et al study (2002) held the belief that science is dynamic and that information was constantly changing as experiments were conducted. The science educators from the Southerland study were all scientists before becoming teachers; therefore, they had a firm grasp of the

scientific process as essential in understanding science, whereas the younger teachers saw facts as more important than the process.

The result of these two differing beliefs was evident in the teaching style of the two groups. The young teachers typically used lectures to instruct the students but also utilized class discussions (Lemberger et al, 1998). Within the lectures, the young teachers mainly discussed facts, with very little mention of the theory in place behind the concepts. Similarly, in class discussions, they asked closed, specific questions. The teachers were uncomfortable discussing areas in which they had little to no background and often gave students textbook answers which did not fully answer the questions posed. When the teachers conducted experiments or other exploratory exercises, they were often “staged” (Lemberger et al, 1998). That is, the students were funneled into having one conclusion by giving them specific information and materials. Overall, the young teachers downplayed the facet of science that is the process of revising existing theories (Lemberger et al, 1998).

The science educators in the Southerland et al study (2002) were teaching in an undergraduate setting. Because of their foundation in the sciences from their studies prior to becoming teachers, they tended to emphasise the process of science in their teaching as well as the facts. None of these educators saw science as concrete (Southerland et al, 2002). These science educators’ curriculum was based on student exploration through a hands-on experience, which was supplemented with lectures and discussions as needed, rather than the more widespread lecture style curriculum used in the Lemberger study. Two of the three educators in the Southerland study felt that students learned best when they did the majority of information gathering for themselves. Having students collect information on their own showed them the importance of process in science, as well as a multitude of different ideas, sometimes contradictory, about certain concepts. Even in lectures, the teachers never gave the students a sense of absolute certainty about the theories they were discussing. The science educators also attempted to tie in the science curriculum to real-life events and situations, which they felt gave the students a better chance of learning the ideas (Southerland et al, 2002).

In both case studies, the individual teacher’s perceptions and beliefs about science influenced the style of teaching employed in the classroom. While the younger teachers from the Lemberger study (1998) used traditional methods, it was the science educators from the Southerland study that created a more engaging classroom environment by using their own experiences as scientists (Southerland et al, 2002).

In addition to looking at how different approaches to the material affected student interest, a number of studies have investigated how a teacher’s knowledge of the materials affects their confidence with science and how that confidence affects their

teaching styles. The results of these studies were examined within a couple of literature reviews (van Driel et al, 2000, Bartholomew et al, 2003). Most science teachers, especially in primary schools, had a basic science background (van Driel et al, 2000). The more experienced teachers held rigidly steadfast to the curriculum they have used in the past. However, maintaining a static curriculum can be unwise, as new developments in science can disprove existing theories (van Driel et al, 2000). Similarly, Bartholomew et al (2003) found that most science teachers in both primary and secondary schools had an adequate understanding of facts, but little understanding of the process and nature of scientific study and thus had a harder time grasping more modern science concepts. Most teachers encounter problems when faced with situations beyond the scope of their knowledge, such as when a student asks a question relating to a theory that the teacher cannot explain (Lemberger et al, 1998). These problems can be remedied by exposing teachers to newer ideas, as well as revamping the curriculum to include more emphasis on the processes important in science and downplaying the need for rote memorization (van Driel et al, 2000).

Based on the responses to the different teaching styles presented in the two studies and the information obtained in the literature reviews, we have concluded that the most effective form of an electronic unit will closely follow the format used by educators in the Southerland study, rather than the format used in the Lemberger study. The educators also indicated that a more process-oriented approach will be more effective, as many of them already have grounding in scientific facts. We hoped that exposing those teachers who lack a background in the sciences to the scientific process would close the gap between these two styles of teaching and perhaps make the sciences a more interesting and accessible field for children.

2.3.2 Interactive Media in Education

Another method of raising student interest in science is through the use of interactive media. The availability of an interactive component within electronic media increases the amount of student learning time (Vockell and Schwartz, 1992) and generates more interest in the scientific process (Southerland et al). Interactive media can sometimes be used in the place of hands-on processes, since obtaining the materials and facilities necessary to conduct those hands-on processes can be formidable obstacles for schools. For example, a micropipette, which is a tool essential within the field of gene technology, costs approximately AUD\$300. Micropipettes are also easily broken. Most schools simply cannot afford to purchase a micropipette for each individual student, or to keep replacing them when they break. The use of interactive media to simulate these types of activities can be a viable and inexpensive alternative to purchasing expensive laboratory equipment.

Computer-based learning can generate interest within a topic by providing an inexpensive, interactive outlet for students to explore that topic. One type of computer-based activity for students can be Java applets or Macromedia Flash animations found on websites. Karkmaz and Harwood (2004) assessed animations that permitted students to rotate a molecule to get a better view of it. In a similar fashion Lee et al (2004) studied students using an animation to watch a simulation of a bullet hitting a suspended block to measure the resulting swing. In both cases, the translation of a scientific concept written in a book to an interactive piece of multimedia on the Internet aided students in grasping science concepts. For example, when using the molecule rotating program, students were better able to grasp concepts like general shape and symmetry (Karkmaz and Harwood, 2004)

2.3.3 Learning Styles

Teaching styles and the tools the teachers use in the classroom are only one aspect of education. Learning styles, the different ways in which students learn, are also important to consider. There are many different classifications for learning styles developed by psychologists and educators. Awareness of learning styles allows educators to understand the needs of students and identify activities that will address those needs. (Verster, Cheron. 2005) The different classification systems for learning styles address different facets of knowledge and understanding. We have examined two classifications of learning styles: modalities and McCarthy's learning styles.

The modalities classification system breaks students into three groups: visual learners, auditory learners, and kinesthetic learners. Visual learners rely on observation of the teacher and often sit towards the front of the classroom. Often, visual learners are said to “think in pictures” (Learning Styles Explained, 2005) and benefit from pictorial or graphical representations of a concept. (Verster, Cheron. 2005). Visual learners also tend to write detailed, lengthy notes during lectures. (Learning Styles Explained, 2005)

Auditory learners gain knowledge by listening to lectures and discussing topics. Very often, written words and textbooks mean little to the auditory learner, unless the words are spoken aloud. Auditory learners often grasp concepts after speaking about them in a casual manner. Reading aloud to themselves also aids auditory learners. (Learning Styles Explained, 2005) Auditory learners will find group discussion or oral exams most helpful to understand a concept or idea. (Verster, Cheron. 2005)

Kinesthetic learners are most attentive during hands-on activities. These students prefer to be active participants in classrooms and often cannot sit still during lectures. Kinesthetic learners want to “actively explore the physical world” (Learning Styles Explained, 2005). Activities such as simple laboratory experiments or model building engage the kinesthetic learner more than lectures. (Verster, Cheron. 2005)

The second classification of learning styles we researched was the McCarthy learning styles. There are four types of learners in this classification: Innovative, Analytic, Common Sense and Dynamic. These learning types were developed by McCarthy in 1980.

Innovative learners desire knowledge to have personal meaning for their life. Innovative learners often use their own values to make judgments. They also enjoy social interaction and tend to be cooperative when working with others. Innovative learners are often idealistic and have dreams of bettering the world through their own actions. Innovative learners enjoy group work, especially when value-based decisions are required. (Verster, Cheron. 2005)

Analytic learners strive to develop intellectually through learning. They prefer fact and show a strong desire to “know important things” (Verster, Cheron. 2005). Analytic learners are often quiet, patient and self-reflective people, who have a strong desire to provide the world with more knowledge. Students with these traits learn best by simply being given facts about the topic. (Verster, Cheron. 2005)

The Common Sense learner enjoys finding usefulness in the topic. Common Sense learners are often also kinesthetic learners and prefer to put any knowledge to a practical use and devise a solution to a problem. Common Sense learners are often impatient and would prefer to actively solve problems rather than think about those same problems. Students with this cognitive process often learn best from hands-on projects mimicking real-life situations. (Verster, Cheron. 2005)

The final McCarthy type learner is the Dynamic learner. Dynamic learners often rely on their instinct when learning and often are aware of more subtle subtopics within a particular field. They also tend to be enthusiastic and outgoing, as well as preferring to synthesize information from various sources. Challenging problems will most likely please the Dynamic learner. (Verster, Cheron. 2005)

While each learner represents a stereotype, both classifications cover many of the common students in most classrooms. A teacher can never cater to all students with any one activity or lecture, but by being aware of the different learning styles the teacher may be able to provide a well-rounded lesson plan, so that each student-type will have the chance to excel.

2.4 Student Learning Assessment

When looking at the teaching and learning of a subject, the materials and techniques that teachers use to gauge student absorption of information by students is always important. A primary goal in the implementation of an electronic unit is lightening the workload of the teacher as much as possible, providing them with more

time to spend on interacting with students, rather than themselves learning and preparing information. If the material within an electronic unit is presented in a manner that illustrates how the teacher can effectively gauge student absorption and retention of the information, then it will be more useful for the teachers and increase the desirability of the electronic unit.

Wragg (2001) discusses two main types of assessment: formal and informal. Within each type of assessment, the activity or test can be written or oral and distributed to either individual students or groups of students. Typically, formal assessments are written and informal assessments are oral. Individual assessment is often easier to gauge, however there are different benefits to group work, such as the development of and improvement in social skills. The type of assessment used is dependant on what the teacher hopes to judge and what knowledge they hope to ascertain. There are four core areas that can be assessed: knowledge and understanding, skills, attitudes, and behaviour (Wragg, 2001.)

There are a number of common errors in assessment that Wragg (2001) warns against. One such pitfall is creating an assessment that is testing some secondary factor instead of what the teacher wanted tested. For instance, if the teacher is questioning a student on a mathematical sum, using the simplest language possible increases question validity. Wragg acknowledges that there is always a language component in any assessment, especially written, that will assess not only the student's understanding of the topic matter, but also of the language and vocabulary used in the question. Also, a teacher should create an assessment that is appropriate for the content taught in the class and is an accurate representation of the time spent on each sub-topic (Wragg, 2001.)

Informal assessment is sometimes written, but is more often oral in the form of direct questions from the teacher to the pupil (Wragg, 2001). Teachers assess their pupils using informal questions for a variety of reasons, such as checking prior student knowledge, ensuring that students are following along during a lecture, or obtaining an idea of how well the students can explain their position. When using a questioning method, the teacher should have a clear idea of what answer they hope the student will provide. If students are unable to provide this answer, the teacher needs to be able to guide the student towards a valid conclusion using more probing, direct questions. Without this feedback, the pupils are likely to feel lost and misunderstand the purpose of the question. Wragg (2001) also advises teachers to use follow up questions after a series of yes or no questions. Even if students answer the yes or no questions correctly, they may not fully understand the concept or fact that the teacher was trying to convey. This problem is especially common in the subject of science, where students are often able to give correct, factual knowledge but lack comprehension of the underlying principles or the relevance of the knowledge. In such cases, the teacher should question the student

until he or she is convinced the student comprehends the complexity of the topic (Wragg, 2001).

Assessments may be used by a teacher either on their own or in tandem with other materials. A teacher giving a test to students or holding a discussion on a topic are good examples of stand-alone assessments, while questions to students throughout the course of a lecture or included at the end of an activity asking them to explain what they have just learned show how it can be used to complement other materials.

2.5 Electronic Resource Design Guidelines

Because of the electronic nature of our project, it was important to look into guidelines for creating electronic resources in addition to guidelines being used in the creation of unit content. These guidelines illustrate how to design electronic media, so that we can produce effective design that conforms to industry standards.

2.5.1 General Web Layout

One of the major components of any electronic design is the general layout of webpages. This layout is created to ensure the ease of use of the resource. Designing a site for 800 by 600 pixels of screen resolution and limiting the usage of frames within the site will help insure that it functions correctly on the average computer (NCI, 2005.) The majority of the Internet community uses a monitor resolution of 800 by 600 pixels, so care should be taken to design the site with this fact in mind. Frames should be avoided as they may react unexpectedly to the use of the web browser's "Back" button and may confuse the average user (NCI, 2005.) The recommendations also mentioned the importance of being consistent in the positioning of elements within each page. These elements become helpful points of reference within the page, allowing a user to better navigate within the site and giving them visual clues if they navigate away from it (NCI, 2005.) Including logos within the site can also provide users with a sense of consistency and act as indicators if the user navigates away from the site. Logos can help to remind users of where they are and remind them of whose web site they are currently viewing. Users generally are not aware when they transition from one web site to another and placing the web site's name or logo on every page helps to alleviate this problem (Nielsen, 1999.)

2.5.2 Content Layout

The importance of useful content within a site is emphasized as more important than the page style (NCI, 2005.) Using descriptive titles and headings within a page will assist the user in finding the information they are looking for quickly. The content should also be spread out to increase readability, with no more than twenty words in any sentence and five sentences in any paragraph. In addition to spreading text out within a

page, it is often wise to utilize hypertext to break up large pages into several smaller ones that each focus on a specific subtopic. Breaking up larger pages into several smaller ones helps users to focus on topics that are of interest to them and ignore those that they do not find to be interesting. (Nielsen, 1999.)

Content presented in an electronic format also provides a unique opportunity to make use of interactive and engaging multimedia elements such as audio and video. In fact, users perceive this ability as one of the most important aspects of electronic resources (EBONI, 2005.) Therefore, it is important to provide these types of interactive multimedia to end users within electronic resources. Multimedia elements can provide a greater sense of engagement to users when they utilize the electronic resource, but it is also important to provide textual descriptions of what occurs within multimedia (EBONI, 2005.) It is also suggested that all interactive multimedia have user controls such as start and stop buttons integrated into them, providing the ability to better control the media.

2.5.3 Resource Navigation

When a web site is made up of more than one page, how users navigate between pages becomes important. Several guidelines suggest keeping all of the navigation aids in one area. Centralising navigation helps the user create a mental model of the site and simplifies navigation (NCI, 2005.) Maintaining a consistent look within navigation aids is also important, as users will only internalize one model of a particular web site. Changes may confuse them and make it difficult to find particular sections within the resource (NCI, 2005.) There are two major components to creating a good navigation aid: hypertext links and indices (NCI, 2005.)

Within an electronic resource, it is often effective to utilize hypertext to enhance navigation and create a cross-referencing structure. The ability to cross-reference information within a resource is a feature that "...readers strongly value." (EBONI, 2005.) Hyperlinks between related documents can assist users in finding information. In order to generate the maximum possible amount of "perceived clickability" hyperlinks should be both coloured and underlined. This prevents users from having to move the mouse cursor over every word inside of a web page in order to find out where they are allowed to click (Nielsen, 2004.) All non-hyperlinked text contained within a web page should not be coloured or underlined, in order to accentuate the fact that coloured, underlined words within the page represent hyperlinks (Nielsen, 2004.) Hyperlinks which point to pages the user has already viewed should be a different colour than unvisited hyperlinks. In 2004, Nielsen pointed out that approximately seventy four percent of web sites utilized different colours to represent visited and non-visited hyperlinks. This percentage illustrates the fact that differently coloured hyperlinks represent a strong convention that most users expect. A standard convention followed by

most web sites is that non-visited hyperlinks are some shade of blue and visited hyperlinks are purple or some other “washed-out” colour (Nielsen, 2004.) Another guideline is to ensure that a page never contains a hyperlink back to itself. Self-targeted hyperlinks tend to generate confusion within a user, as the page does not seem to change when the user clicks that hyperlink (Nielsen, 2004.)

According to the Electronic Books On-Screen Interface guidelines (EBONI), it is important to include an index when designing electronic resources. Indices provide a method for users to quickly locate information on specific topics within the electronic resource. EBONI also states that using hyperlinks within an index can be an effective navigational tool. Such an index should be placed prominently within the electronic resource, rather than at the back (such as in a paper book) (EBONI, 2005.) Topics should be ordered within an index so that they appear in order of relative importance, with the most important topics appearing at the top of the list (NCI, 2005.)

Including a search feature within an electronic resource can also be effective. The search feature should be intelligent enough that it simulates the way that a user would search through a paper book. Creating such a search feature can be accomplished by providing options to search through specific chapters, pages, or paragraphs. These search features should not replace traditional indices and tables of contents, however. (EBONI, 2005.)

2.5.4 External Hyperlink Guidelines

The last area that was discussed when dealing with electronic resources was maintaining a controlled environment. It should be possible to treat electronic resources as a closed environment, which means that it should not be necessary for any component of the resource to require access to some other resource. External hyperlinks must be clearly labeled as such, in order to avoid user confusion about what resources are parts of the electronic resource and which components are pieces of external resources (EBONI, 2005.) During a psychology experiment conducted by EBONI, it was found that not labeling external links clearly had a tendency to cause users to become “lost in hyperspace.” One participant in the study stated “I kept getting lost and straying into other parts of the Web” (EBONI, 2005.) Therefore, all hyperlinks that direct a user to an outside source should be clearly labeled as users tend to assume that hyperlinks will stay within a site (NCI, 2005.)

2.6 Published Lesson Plans for Teachers

One of the best ways to understand how to create electronic educational resources is to examine existing examples. There are many online resources available for teachers, usually produced by scientific organizations. In the United States, The Discovery Channel provides cable television subscribers with scientific and educational

programming. To supplement this programming, the company provides a website with resources for teaching, including sample lesson plans that contain curriculum requirements (www.discoveryschool.com, 2005). The areas covered are typical in middle or high school science classes and include genetics, chemistry, the solar system, viruses and bacteria, and magnetism (<http://school.discovery.com/curriculumcenter>). Each lesson plan typically gives a list of interesting facts related to the topic area in order to help teachers attract students' attention. The suggested activities also include some simple experiments to be done to demonstrate a key concept in that particular area. In the genetics lesson plan, for example, one experiment describes pulling red and white beans out of a jar to explain the random selection and independent assortment of genes (<http://school.discovery.com/curriculumcenter/genetics/activities.html>). Also, the website lists a few discussion questions to stimulate student interest in the scientific subject, as well as a glossary of terms and a word search or other word puzzle to familiarize students with the terminology of the science. Teachers have the flexibility of choosing activities that they feel give students the best opportunity to learn the material.

Another resource with a large collection of lesson plans is the Smithsonian Institute. The lesson plans offered by the Institute cover a wide range of topics and are designed to complement a visit to a particular museum exhibit (http://www.smithsonianeducation.org/educators/lesson_plans/lesson_plans.html). While the lesson plans vary in content and activities, most include handouts for students to familiarize themselves with the topic. These are simple, basic and concisely written. In addition to handouts, most lesson plans include a variety of activities that focus on a particular aspect of scientific inquiry, such as developing a hypothesis or creating a procedure for investigation of a question. These activities integrate specific science knowledge with general scientific tools such as experimental design. Because of this integration, these lesson plans provide powerful tools that can foster scientific curiosity within students (www.smithsonianeducation.org).

3 Methodology

To accomplish the goals of our project, it was first necessary to conduct investigative research on what was both desired and needed in an electronic unit, as detailed in the previous chapter. We then developed a framework for electronic extensions to CSIRO Education Victoria workshops while considering those needs and desires. Then, a specific workshop was chosen as a basis for the implementation of the framework. Content was generated for the workshop topic and then implemented into a complete electronic unit using the newly created framework. Finally, the implemented framework was assessed by CSIRO staff and Victorian teachers. In this chapter, we will discuss the steps outlined above.

3.1 Framework Development

One of the main tasks of this project was to design and develop a framework that CSIRO Education Victoria could use to implement electronic units for its Science Education Centre programs. To accomplish this task, we utilized an iterative design process where we followed a series of steps in a predetermined order, received feedback from CSIRO Education Staff on the results of those steps, and then repeated the process using that feedback. By receiving feedback on the design of the framework throughout the entire development process we were able to iteratively implement many of the suggestions given to us by CSIRO Education Victoria staff. This style of design process generally results in a higher-quality product; one that is custom-tailored to the needs of the client.

Before it was possible to design a framework that would meet the needs of CSIRO Education Victoria, it was important to define what their needs were. This was accomplished through interviews with CSIRO Education Victoria staff. To fulfill those needs, we generated three goals that our framework would need to accomplish in order for it to be valuable to CSIRO Education Victoria.

The first goal of the framework is that it is topic independent, so that the framework is applicable to any workshop. The primary need of CSIRO Education Victoria is for a design that they will be able to use to implement electronic units for any of their workshop topics. Therefore, it is vital that the framework is not tied to a specific workshop. A framework design that relies on a specific facet of a certain discipline of science will be ineffective.

CSIRO Education Victoria has also expressed a desire for a design that is extendible and easily updateable. The design must be such that the framework is easy to utilize by staff members of CSIRO Education Victoria, many of whom do not have a high degree of computer literacy. In addition, it must be easy to update existing information

within an electronic unit implemented using the framework and to add additional information or resources to an electronic unit.

Third, the design must be marketable to the target audiences, which are teachers who have ordered a CSIRO Education Victoria workshop and are looking for additional support materials to use during their classes. Therefore, the electronic unit must be structured in a way that is desirable to the target audience. To achieve this goal, it will be necessary to test the final electronic unit extensively while focusing on unit usability, layout, and structure.

Next, we determined what the framework should contain. To accomplish this task, it was necessary to attend several of CSIRO Education Victoria's workshops in order to determine the general workshop format and structure. Observing the workshops was of critical importance because the framework needed to be designed in such a way that it produced electronic units that complement those workshops that already exist. We observed workshops across many different subjects, so that we could draw conclusions from these observations that would apply towards the framework while maintaining a sense of topic-independence.

While attending these workshops, we interviewed the teachers whose students were participating in the workshop to determine exactly why the teachers were utilizing the workshops. It was important to consider why teachers used CSIRO Education Victoria workshops if we were to design a framework that generated effective and useful electronic units.

CSIRO Education Victoria gives a set of teacher materials to teachers at the conclusion of each of its workshops. These materials are provided in paper format and contain additional information regarding what happened within the workshop. We examined the teacher materials from several different workshops to maintain a sense of topic-independence and identified those common areas and features that we felt were effective and those that we felt could be improved upon.

Along with the packet of teacher materials, CSIRO Education Victoria also distributes a workshop evaluation form. We examined these evaluations and identified aspects of CSIRO Education Victoria workshops that teachers felt were useful and which aspects teachers found to be inadequate. We used the evaluations from several different workshops to maintain a topic-independent perspective. The information within these evaluations was considered heavily when designing the framework.

We utilized the information gathered above to construct a framework that can be used to generate complements to the workshops. We considered the opinions of teachers as well as the opinions of CSIRO Education Victoria staff throughout the entire iterative design process. For additional information regarding our implementation of the

framework, please refer to Chapter 4. For additional information regarding how the CSIRO Education Victoria staff evaluated the validity and effectiveness of the framework, please refer to section 3.3.

3.2 Content Generation

Content generation refers to the development and creation of topic-relevant materials for the electronic unit. The materials and information gathered will then be implemented into an electronic unit by utilizing our framework. There are two main factors involved in content generation: identification of appropriate topics, and content creation.

The principal topics of our content were identified through workshop observation. The topics central to the workshop became the core content of the electronic unit and additional topics were determined through informal interviews with both Victorian teachers and CSIRO Education Victoria staff. These interviews indicated areas where additional information would be of benefit to Victorian teachers. The staff also provided their opinions on the data we had gathered from the teachers and commented on the feasibility of providing materials for each of those topics. Finally, a comprehensive set of topics relating to the workshop was developed while considering the suggestions of the teachers and CSIRO Education Victoria staff.

Once the topics were chosen, we researched them using textbooks, current scientific journals, and reliable Internet sources. CSIRO Education Victoria staff assessed the information in order to ensure correctness and appropriateness to the school year level. This process was iterative; content was generated, then assessed, then modified in this manner until the information was appropriate. This information was then implemented into a complete electronic unit by utilizing the framework described in section 3.1.

3.3 Unit Assessment and Testing

While constructing the electronic unit, it was important to test both the effectiveness and the accessibility of the design described above. The initial testing was performed using CSIRO Education Victoria staff and their comments were used to refine individual portions of the unit. We then brought the implemented unit to both the CSIRO Education Victoria staff and the teachers who were experiencing the Gene Technology workshop and used their comments to evaluate the unit.

3.3.1 CSIRO Education Officer Evaluation

Before demonstrating our electronic unit to teachers, we first tested it using several of the CSIRO Education Victoria staff members to get their impressions of the material covered. These staff members had prior teaching experience that enabled them

to provide useful feedback regarding the quality of our educational unit, both in terms of content and layout. These evaluations were conducted iteratively; the results of each of these evaluations were incorporated into the electronic unit before the next evaluation was conducted. The evaluations allowed us to examine the information provided within the unit and test it for accuracy, the level of difficulty of the material, and whether or not the topics were suitable for students in years nine and ten. Much of this feedback aided in the iterative design process. The background information in particular developed fully after several revisions. Two experts on gene technology, Drs. Merrin Fabre and Rebecca Carter, were consulted as to the validity of the information and provided valuable feedback. We utilized this feedback to increase the quality of the background information throughout the electronic unit.

In addition, the activities and multimedia were evaluated by CSIRO Education Victoria staff to determine the educational usefulness of those activities and multimedia. We focused on evaluating the age appropriateness, relevance to curriculum standards, and overall quality of the activities and multimedia during this phase. Because CSIRO Education Victoria already incorporates activities and multimedia into their presentations, they were able to give us feedback based on their experiences. The feedback was gathered while development of the electronic unit progressed and activities and multimedia were iteratively altered to address the comments of CSIRO Education Victoria staff.

3.3.2 Teacher Evaluation

After gathering the opinions of CSIRO Education Victoria staff regarding the unit, we surveyed teachers in Victoria. We approached teachers during the presentation of CSIRO Education Victoria programs and asked them to evaluate the materials and complete a survey. We also contacted teachers that had recently participated in the corresponding CSIRO workshop and sent them a copy of the materials and survey in order to gather feedback regarding the unit from a broader range of teachers. Teachers were the target market for our educational unit; their opinions on the unit helped us determine the marketability of the unit. Also, their experiences as teachers gave them a better understanding of what the effects the activities would have on student learning and interest for their particular class.

Teachers were asked to provide feedback on several different subjects: format usability, content applicability, and content sections. For format usability, teachers were asked to rate how easy they found navigating the layout and locating information within the unit. Teachers were also asked to look at one or two specific sections of the unit and give a more in-depth review of them. They were asked to review and comment on the background information provided in the section as well as any multimedia and activities

provided. Similar to education officer interviews, teachers were surveyed about appropriateness of the materials, as well as curriculum-relevance and content quality. Finally, teachers were asked to give their feedback on the general topics and materials provided and to voice other concerns about the unit. The survey questions can be found in Appendix N.

4 Framework Design

One of the main goals of this project was to design a framework for CSIRO Education Victoria that can be used to generate electronic complements to their existing Science Education workshops. It was therefore important to determine what such a framework should contain. The framework consists of a set of rules, designs, and guidelines that can be used to generate an electronic unit. Within this chapter, we will detail the contents of the framework. We will also determine the distribution method of electronic units implemented using this framework.

4.1 Framework Contents

This framework consists of a series of rules, designs, and guidelines and utilizes the format of an online educational resource. It primarily consists of a set of articles on various topics which all revolve around the subject of a specific workshop. Each article corresponds to one topic. Within each article, there are three subsections: Background Information, Multimedia, and Activities (as seen in Figure 3.) There are also several sections within the framework that do not fall into the article category; namely, the “Careers” section and the “Glossary.”

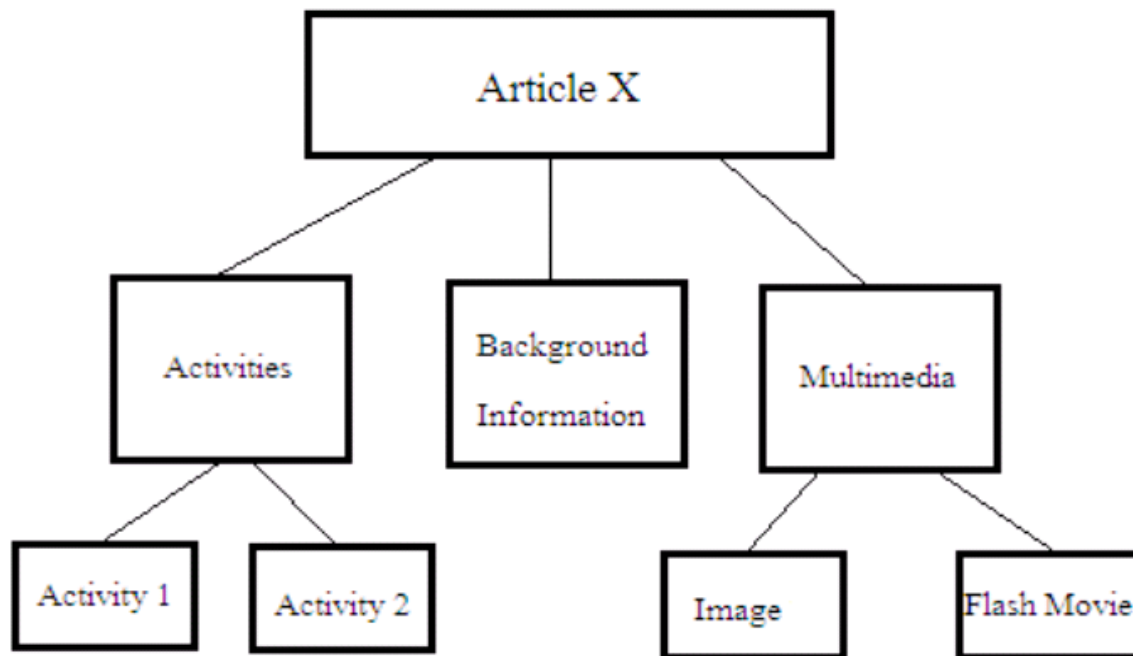


Figure 3 - An article consists of three main sections: background information, multimedia, and activities.

The background information section contains information about each topic within the electronic unit. This section was included within the framework because many

teachers we interviewed expressed a desire for additional information that expanded upon the workshop topics. The background information section contains a sufficient amount of information to explain the topic at hand in a clear and concise manner such that a teacher with minimal knowledge about the subject will understand it. A small amount of familiarity with the topic can be assumed (Chris Krishna-Pillay, personal communication, 2005,) but any terms specific to the topic need to be defined within the unit itself. All keywords within the background information section are hyperlinked to corresponding topic pages if they are contained within the unit. The background information section forms the basis of each article. At the bottom of each background page, there is a section that contains hyperlinks to related web sites on the Internet. Pages that are preferred for this section include official government or university research sites, or links to research done within CSIRO. These types of web sites are preferred because they are officially endorsed by CSIRO, an accredited university, or a research institution and therefore bring credibility to the information conveyed within each background information section. One of the web usability guidelines discussed in the background research chapter indicated that providing hyperlinks to authoritative web sites that validate information within a web site generates a sense of trust in the end user.

Within each article, there is a section containing multimedia to accompany the background information section. In some cases, the multimedia can be directly integrated within the background information section, such as images embedded within the text. But, in all cases, multimedia are all listed within a separate section so that a user can easily view all multimedia contained within an article at one time. Through our background research and interviews with teachers, we found that multimedia such as Macromedia Flash animations can be effectively used to demonstrate concepts that are difficult to visualize. Also, it is a recommended web design practice to utilize informative images to break up text within long articles. This practice makes it easier to read and absorb the information contained within the web site.

Each article also contains an activities section, as desired by CSIRO Education Victoria. Our background research revealed that children learn best when they are engaged in the material and that providing interactive activities is an excellent method of increasing student engagement. In addition, the relation between each activity and the Victorian Essential Learning Standards is stressed, which is intended to boost both the marketability and educational value of units implemented using this framework.



Figure 4 - An index containing the topics within the framework.

Within the framework, there are indices that list all of the topics, multimedia, and activities contained within the unit so that an end user can easily locate specific pieces of information with a minimum of effort. These indices are of comparable quality to those returned during a typical Internet search. There are several ways to sort each index and these are accessible through hyperlinks found at the top of each index document. This feature was included in order to assist users in sorting the information contained within each index into a sequence that they find most appealing. For instance, it is possible to organize the list of topics within the topic index by either workshop relevance (this is defined as how closely related the topic is to the workshop) or alphabetically. This feature is intended to help users find what they are looking for with a minimum of effort. Figure 4 represents an example of an empty index constructed using the framework.

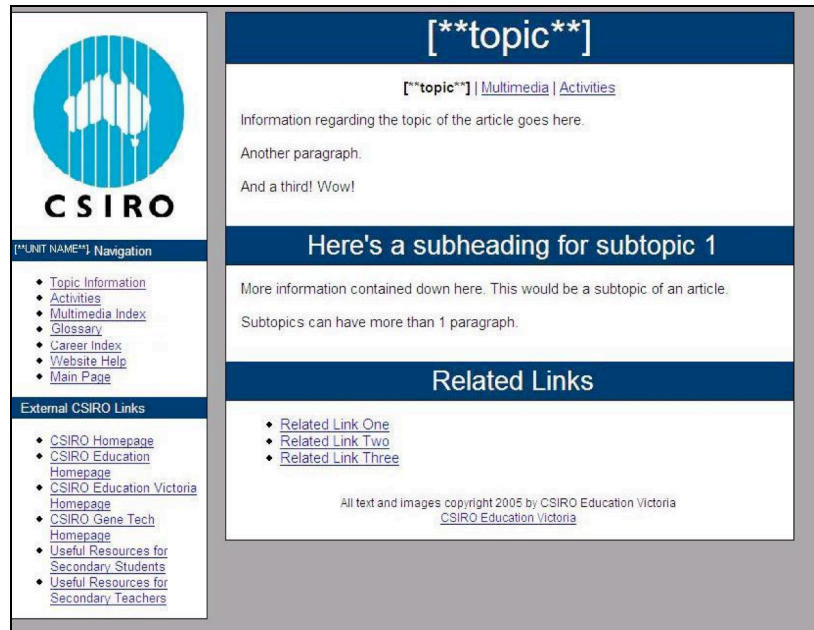


Figure 5 - A blank background information page, which displays the layout of background information pages within the framework but doesn't contain any content.

The layout of every page within the framework contains a navigational bar on the left and the informational content of the page on the right. The navigational bar is identical across each page within the electronic unit in order to maintain a sense of consistency. The navigational bar contains links to each of the indices so that they can be accessed regardless where the user is within the electronic unit. In addition, the navigational bar contains hyperlinks to CSIRO web sites that may be of use to users of the educational unit. These web sites include the official CSIRO homepage, the CSIRO Education homepage, and the CSIRO Education Victoria homepage. The navigation bar can be viewed on the left side of Figure 5. Also, the CSIRO logo is prominently displayed in the upper left hand side of every page within the unit, reminding the end user that they are using a CSIRO product, as recommended by the web guidelines contained within our background research chapter.

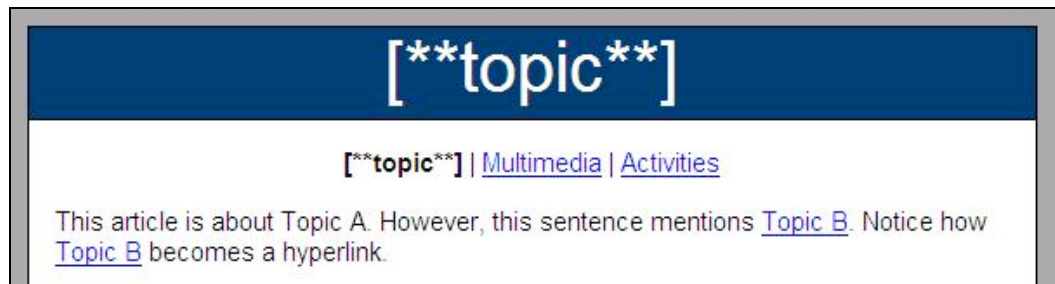


Figure 6 - Screen shot of an article featuring cross-referenced hyperlinks.

The framework also features a cross-referenced structure. Within each page, wherever there is a word for which there exists a corresponding article or glossary definition, the word hyperlinks the user to that other article or definition. An example of this hyperlinked structure would be found within some article about topic A, as outlined in Figure 6. Within that article, there is a sentence which involves topic B, which is a topic with a corresponding web page elsewhere within the electronic unit. The phrase within that sentence in article A that refer specifically to topic B is a clickable hyperlink that brings the user to the web page about topic B. By creating informative cross-references within documents, it will be easy for an end user to successfully navigate an electronic unit implemented using this framework. In addition, almost every teacher that was surveyed was familiar with the concept of following hyperlinks, so this cross-referenced structure should be intuitively understood by most end users.

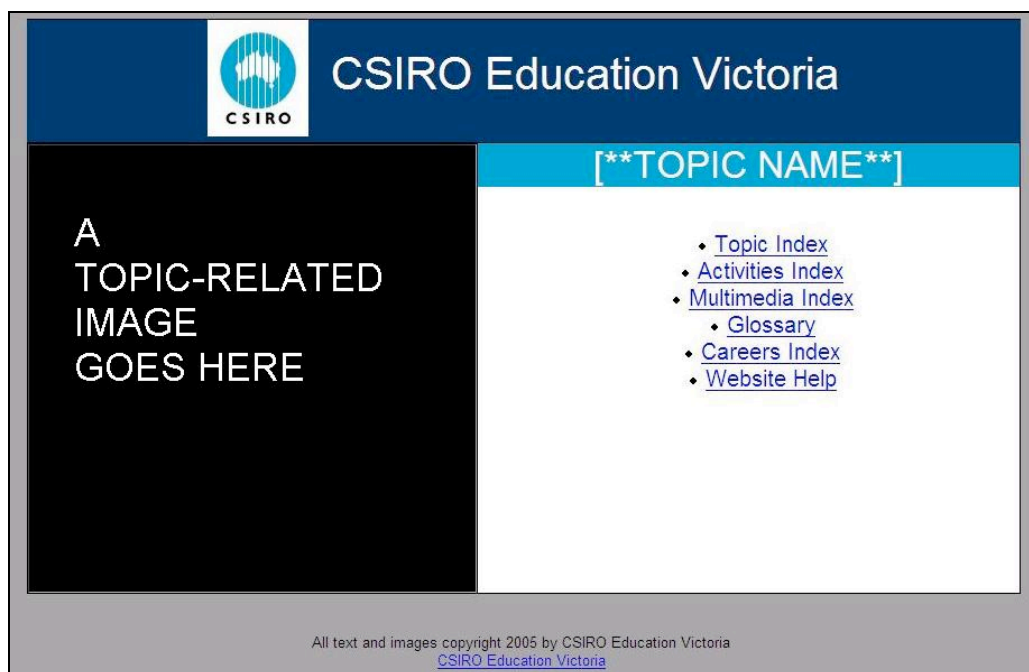


Figure 7 - The main page of an electronic unit.

Within the framework, there is an outline for a main “splash page” (as seen in Figure 7) that is the first page that the user will see upon opening the electronic unit. This page contains the CSIRO logo, a topic-related image, and links to each of the main indices within the unit itself. At any point while using the electronic unit, the user can click a hyperlink for the main page on the navigation bar to return to this main splash screen. This helps to generate a sense of comfort within users, as they can easily return to the initial page with one click.

There is also a section within the framework that contains a glossary of all unfamiliar terms found within the educational unit content. The glossary contains basic definitions for such terms and hyperlinks to corresponding topic pages where those terms can be found. The definitions are brief and are rarely more than one hundred words in length. The glossary is intended to assist teachers who have little prior knowledge of the field. The framework also includes an outline for an index of careers that relate to the content of the educational unit. Several teachers expressed a desire to see how the information contained within the unit applied to work done by scientists.

4.2 Distribution Method

There are many methods that can be used to distribute materials electronically to teachers. The method chosen by this project was that of a HTML-based format that resides on a CD-ROM. There were several factors that contributed to the decision to distribute the materials using a CD-ROM.

Primarily, the desires of CSIRO Education Victoria were considered. From a marketing standpoint, CSIRO staff felt that having a product that they could physically hand to teachers would appeal to them more than giving them access to something ethereal, such as a web site (Chris Krishna-Pillay, personal communication, 2005.) Secondly, there are constraints regarding the design, maintenance, and upkeep of web pages operated by CSIRO, mandated by the central CSIRO office in Canberra, Australian Capital Territory. Websites within the CSIRO organisation must conform to a certain set of guidelines and be built using required templates. These regulations and restrictions would only complicate the design and implementation of electronic units such as the one implemented within this project and therefore an Internet-based format was currently deemed unacceptable, although this decision might be reversed in the future (Chris Krishna-Pillay, personal communication, 2005.) In addition, data gathered by Adams, Doherty, and Smith in 2004 illustrate that four out of every five Victorian teachers surveyed felt that a CD-ROM was a viable distribution method for informational follow-up materials.

A unit implemented using this framework will reside in HTML (web site) format on a CD-ROM. There are several benefits to utilizing this format. The cross-referencing system described in the previous section can easily be implemented using hyperlinks, which are perhaps the most prominent feature of the HTML language. It is safe to assume that most if not all people who eventually utilize units implemented using this framework will be familiar with the concept of hyperlinks. A second benefit is that there exists a wealth of HTML editors, such as Macromedia Dreamweaver or Microsoft FrontPage, available to the public. These tools make it easy to update, edit, or create HTML documents. Another benefit to a HTML-based structure is that almost every computer sold within the last ten years includes a web-browser (such as Microsoft Windows' Internet Explorer, Macintosh OS X's Safari, etc.) so it will possible for anyone with a computer to browse the units. In addition, the end users will most likely be familiar with utilizing a web browser, so there will not be an initial learning curve where they familiarize themselves with the software.

A potential benefit to the CD-ROM based distribution method is that since the units themselves will be implemented in the form of a hyperlinked set of documents, it will be easy for CSIRO Education Victoria to transition from this CD-ROM based format

to an Internet based format if they so choose. The materials within each unit will already be in a structure acceptable for the Internet. By providing a framework that already utilizes such a structure, the possible future transition from CD-ROM to Internet will be simple. In addition, the framework utilizes the official CSIRO color scheme so that all electronic units implemented will have a consistent look and feel that is common across all of CSIRO's web sites.

A major drawback to a CD-ROM based format is that it is no easier to update a CD-ROM than a set of printed materials, such as the ones currently distributed to recipients of CSIRO Education Victoria programs. When a CD-ROM is created, the contents of the disc are burned into a reflective lining within the disc itself and once that initial burning has completed, the CD-ROM is unchangeable. If, for example, a CSIRO Education staff member wants to add additional scientific information to an already burned and distributed unit, it would require burning new copies of the CD-ROM media and any copies of the old version of the unit would become obsolete.

A search feature for the CD-ROM would prove to be very effective, but due to technological limitations of distributing units on CD-ROM, such features are impossible to implement. These limitations result from the fact that when a user queries a search engine or search facility, the engine uses data contained within its local system to return results to the user based on that query. Since the unit will be residing on a CD-ROM, there will be no data contained within the users system to respond to that query. While browser plug-ins such as Java applets, Macromedia Shockwave, and Flash are designed to execute within a web browser using an interpreter, none of these are suited for the development of a search utility.

Another factor to consider along with the CD-ROM distribution method is that the framework cannot assume that an Internet connection is present on all machines. It would not be effective or reasonable for a system distributed on a CD-ROM to require access to the Internet in order to function. In addition, the use of browser "plug-ins" such as Java applets and Macromedia Flash must be judicious, as it cannot be guaranteed that an end user possesses the necessary software on their computer to utilize the plug-ins. Therefore, it is important to provide hyperlinks to the locations where the end user can download the necessary software or copies of the software on the CD-ROM itself.

5 Gene Technology Unit Content

The other main goal of our project was to implement the framework outlined in Chapter 4 fully by designing and creating articles, activities, multimedia, glossary, and career index for the Gene Technology workshop. We considered topics for inclusion in the unit, as well as articles, activities, and multimedia related each topic. The design of the content was based on surveys and interviews with CSIRO Education Victoria staff and Victorian teachers, as well as background research completed for each topic as described in section 3.2. Throughout the process of implementing the unit, CSIRO education staff periodically reviewed the content, multimedia and activities. The staff's input allowed us to ensure that information was accurate and reflected well upon CSIRO. Figure 8 shows the main page of the Gene Technology unit. The complete website is available on this report's companion CD-ROM.

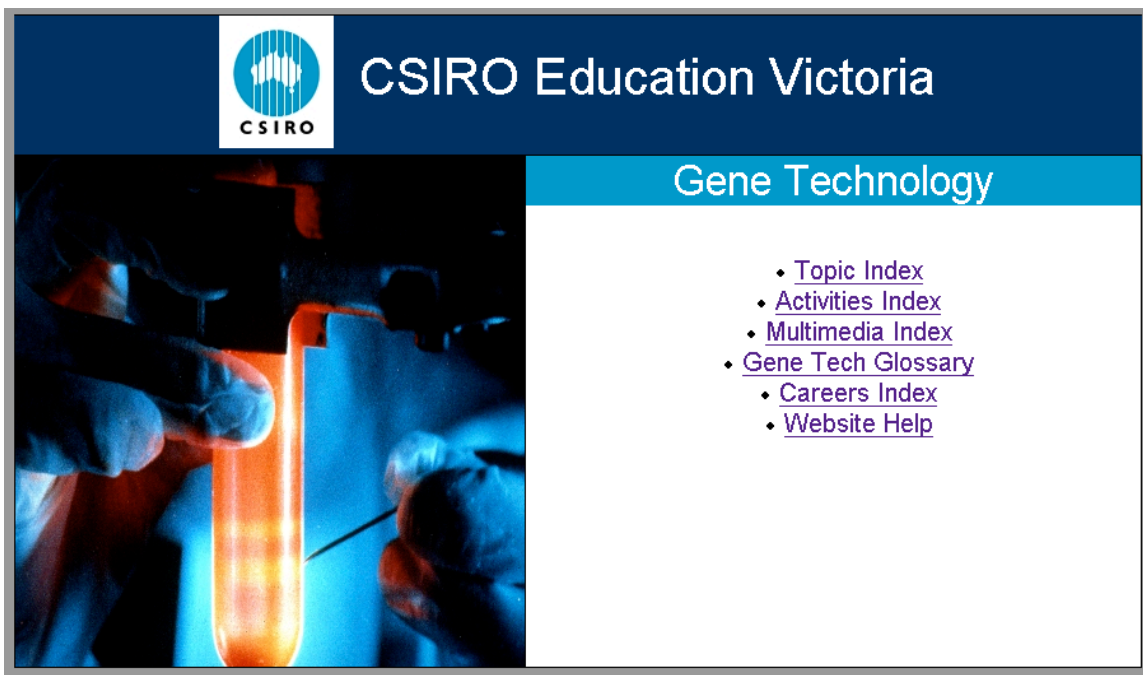


Figure 8 - Gene Technology main page

5.1 Topics Covered in the Unit

There are ten topics covered in the gene technology unit: Gel Electrophoresis, DNA Extraction, Restriction Enzymes, Cloning, Stem Cells, Polymerase Chain Reaction, Genetically Modified Crops, Common Laboratory Equipment, The Human Genome Project and Careers in Gene Technology. The topic index is accessible from the main page (see Figure 8). Figure 9 shows part of the topic index, completed with gene

technology topics. Refer to Appendix J for more detailed descriptions of the content of these topics.

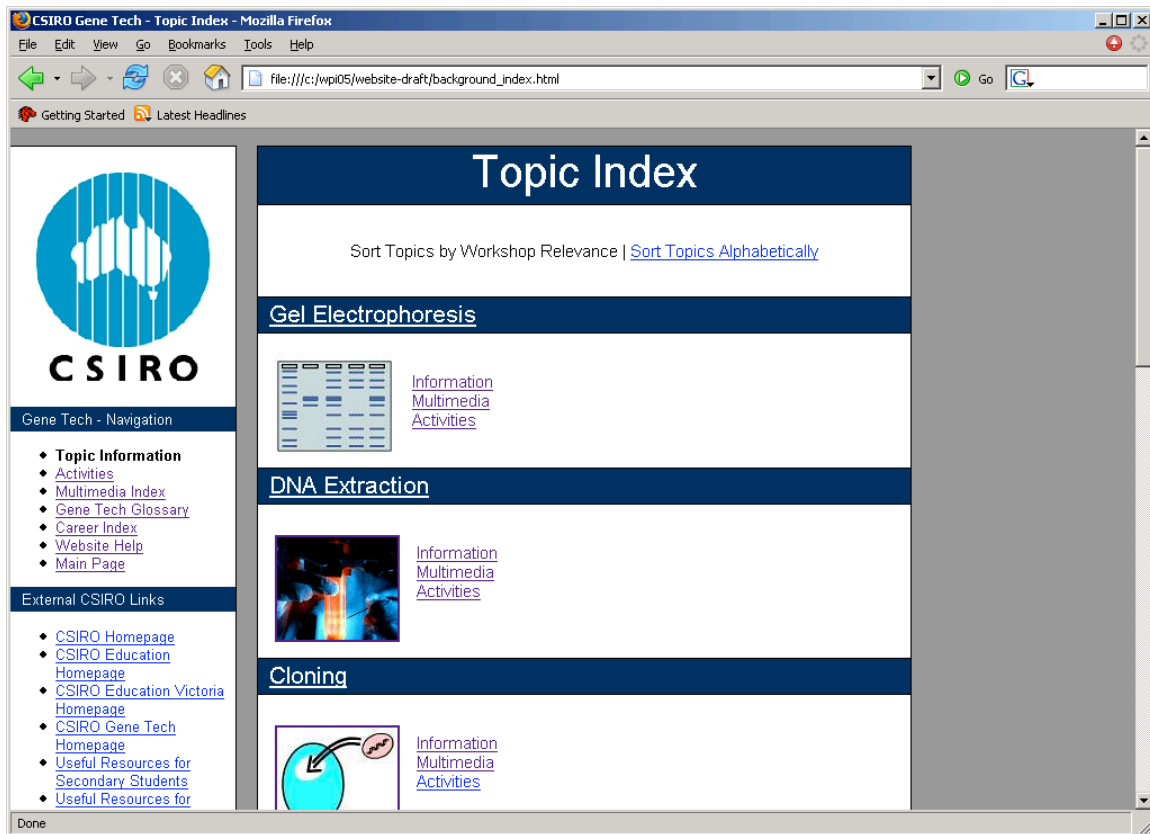


Figure 9 - Gene Technology topic index

Gel electrophoresis and DNA extraction are the two experiments in the Gene Technology workshop. CSIRO Education Victoria staff stressed the importance of inclusion of these topics so that teachers can continue discussion of those workshop topics and allow students a chance to see the workshop material from a different perspective. Common laboratory equipment, restriction enzymes and polymerase chain reaction are all extensions of information from gel electrophoresis and DNA extraction. Both teachers and CSIRO staff felt that a graphic description of laboratory equipment would aid students in remembering the workshop. Restriction enzymes and polymerase chain reaction are both advanced topics. Restriction enzymes, which are briefly mentioned in the workshop, are a topic that some teachers identified as difficult to understand. CSIRO Education Victoria staff noted that polymerase chain reaction is a common procedure for gene technology, but is often difficult to explain.

During interviews with CSIRO staff, the topics of cloning, stem cells and genetically modified crops were identified as important because of the ethical discussion they create. During interviews, teachers expressed interest in continuing the cloning debate that the Gene Technology workshop began. Students and teachers do not need to

have in-depth knowledge of these particular topics in order to discuss the social and ethical implications of the technology; however, a basic overview of cloning can be helpful. Because of the input from the CSIRO staff and the interest of teachers, cloning, stem cells and genetically modified crops have been included as topics in the unit.

Several teachers also expressed interest in a section discussing careers in gene technology. Understanding the relationship between genetics learned in secondary school and its use in professional careers addresses the “Science at work” dimension of VELS. The career section not only involves careers in science, such as geneticist or cell biologist, but also careers such as lawyers who deal with ethical questions or anthropologists studying ancient genetics. By providing this mix of careers, teachers can help students understand the pervasive nature of science and genetics in modern society. The careers section also discusses current CSIRO work in gene technology, which is a desirable feature for our unit according to CSIRO staff. A number of careers link into CSIRO’s website, where applications through research are illustrated. Figure 10 is a screen shot of part of the careers page.

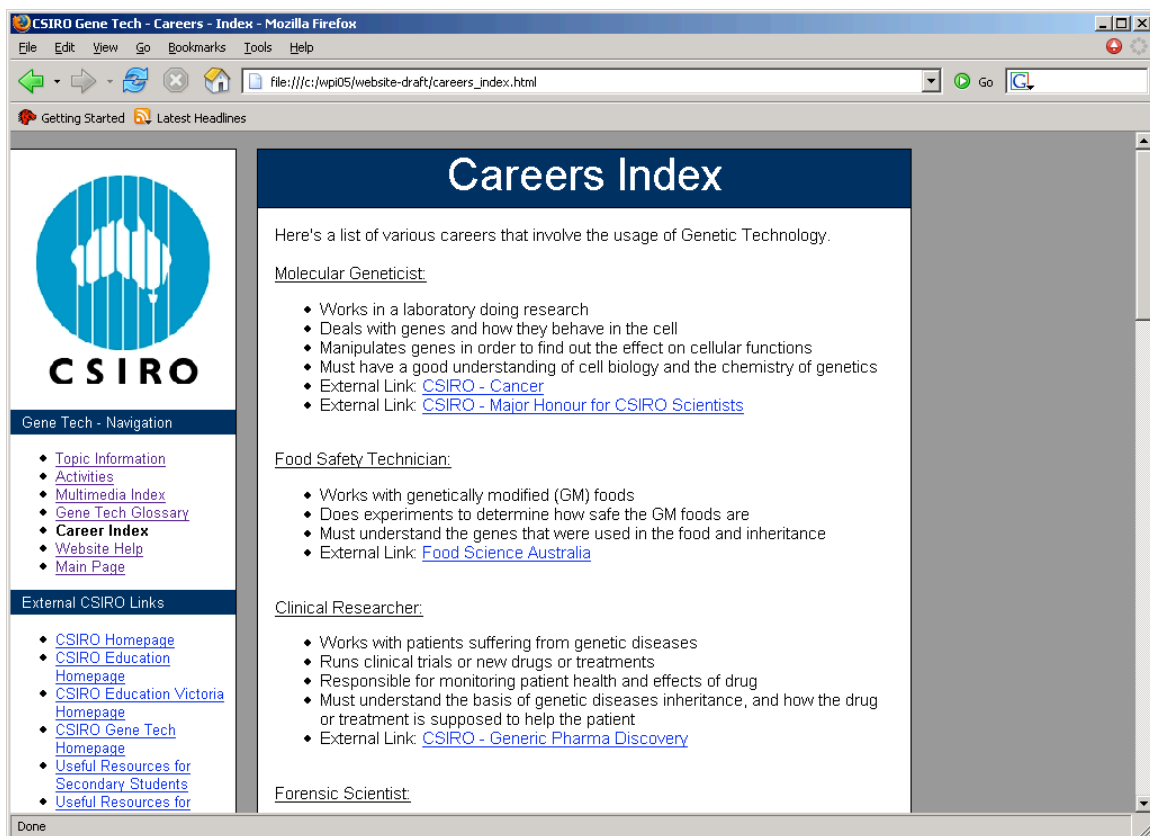


Figure 10 - Gene Technology career index.

These ten topics expand upon the Gene Technology workshop, providing a comprehensive complement to the workshop. Each topic is independent; however, the links between topics are stressed through hyperlinks between key words and articles.

5.2 Gene Technology Articles

The topic articles contain relevant background information, as well as current scientific advances pertaining to each topic. The background information encompasses important vocabulary, examples of use in a laboratory setting and visual aids. The background information is intended for teacher use; however, the multimedia is designed for both teachers and students. Figure 11 shows an example of an article, which is accessible from the topic index seen in Figure 9.

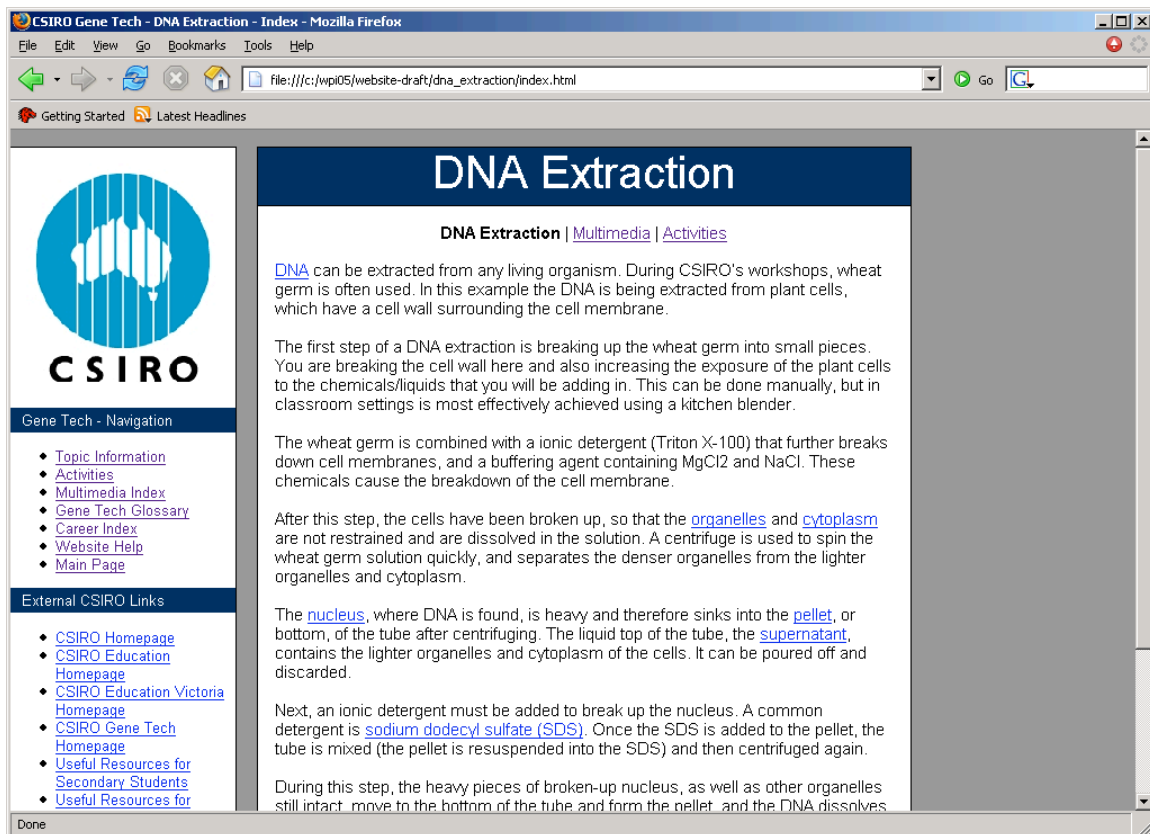


Figure 11 - Screen shot of DNA Extraction article, showing linked terms and general layout.

While each article varies in specific content, there are general issues that were considered for all topics. One such issue is that of level appropriateness. The topic choice, as well as the way it is written, must be applicable to years 9 and 10 (the target audience of the Gene Technology workshop) and easy to understand for teachers of those years. According to interviews with education officers, teachers at that year level often have a strong science background, but may be uninformed about modern techniques or discoveries. Some knowledge of general background information on genetics can be assumed, however specific background knowledge on each topic must be provided (Chris Krishna-Pillay, personal communication, 2005.) All background information was

reviewed by two experts from CSIRO. Any misrepresentations or unclear explanations were identified by these experts, then appropriate changes were made to the background information.

Another issue central to all topics was the design of the multimedia. Most of the multimedia included within the unit was created in Macromedia Flash, a program that allows the user to develop animations. Each Flash animation was created to complement pieces of the content information that may be difficult to visualize. Figure 12 and Figure 13 show static views of the multimedia. Figure 12 shows a screenshot containing information about restriction enzymes. The animation automatically pauses at this point and the teacher can proceed with the animation by pressing the “Play” button. Figure 13 shows another part of the animation where the action of the restriction enzyme is shown.

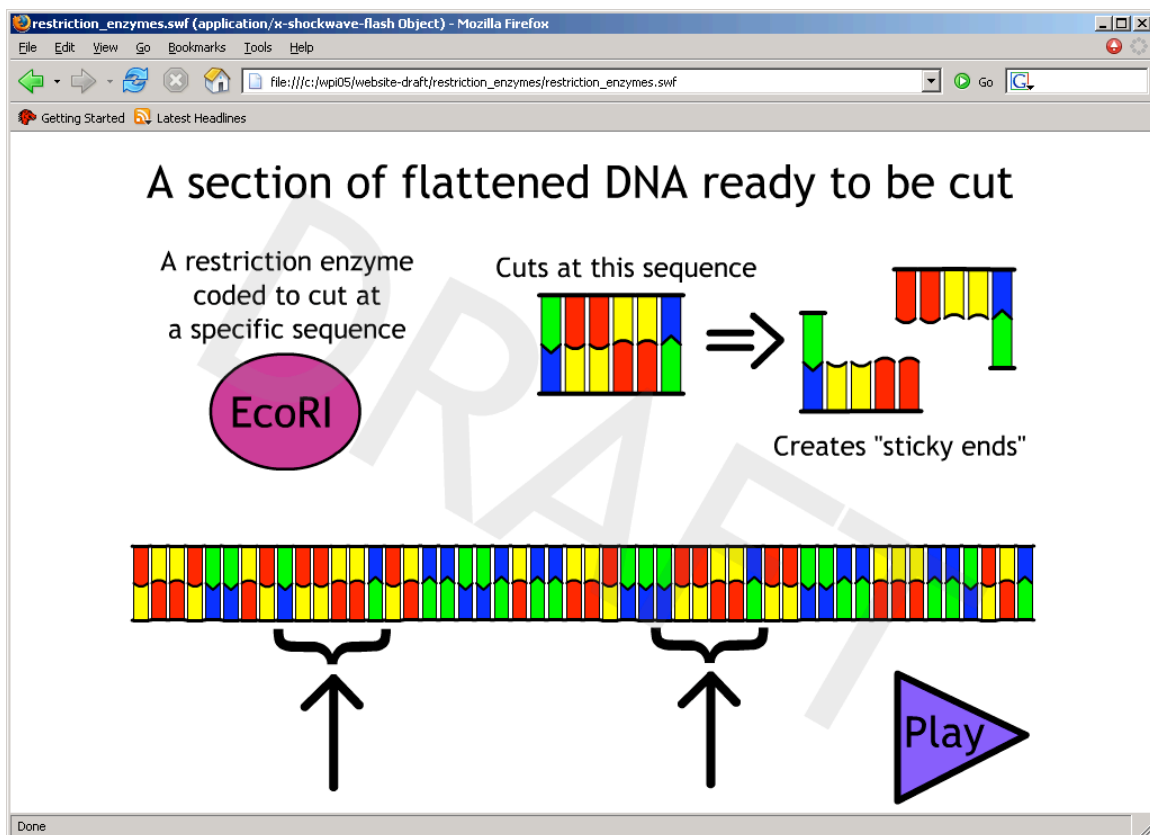


Figure 12 - Restriction Enzyme screen shot (paused screen).

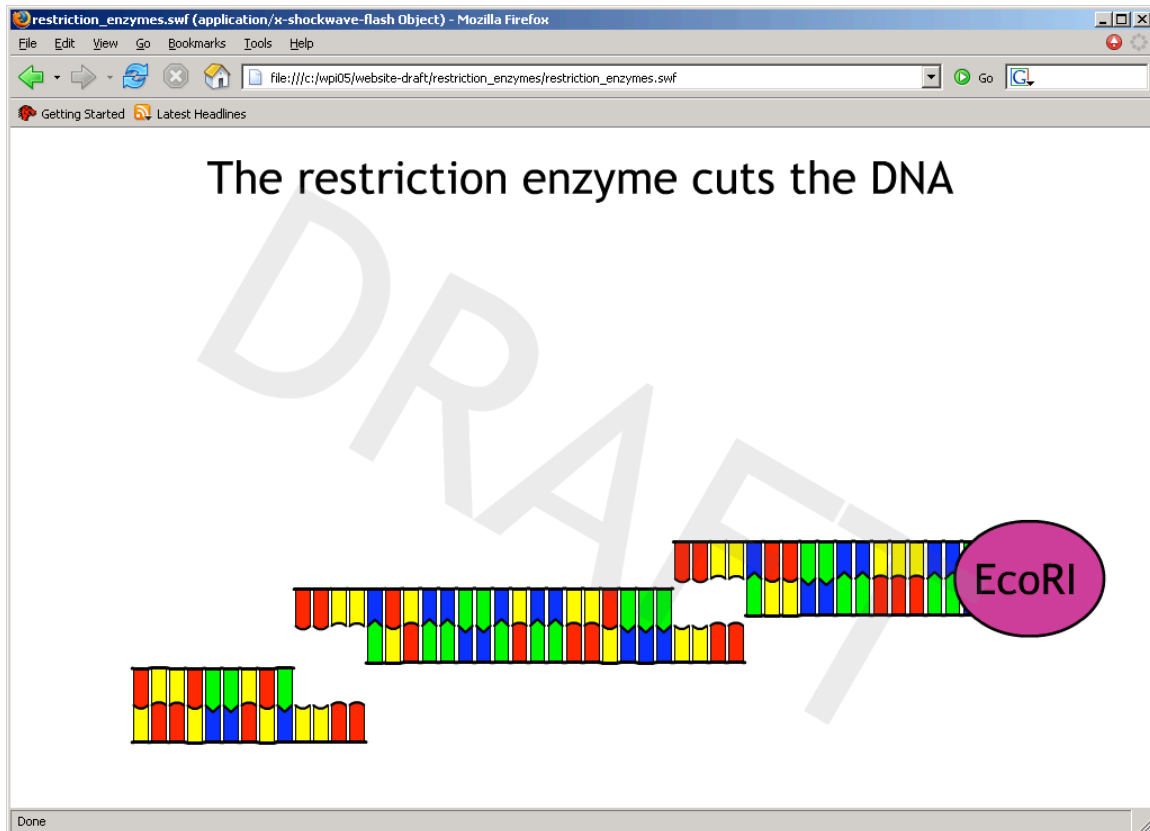


Figure 13 - Restriction enzyme screen shot (action)

In their assessment of the animations, education officers described them as simple and to the point and noted the possibility that these animations will aid teachers and students in understanding some of the important aspects of gel electrophoresis, restriction enzymes, cloning and polymerase chain reaction. These topics are often very abstract and difficult to understand because they occur on a cellular or molecular level. Other multimedia included digital photography of laboratory equipment and laboratory techniques. Students are exposed to both the equipment and the techniques during the workshop, but do not display accurate recollection of these topics according to education officers and teachers. Since most schools do not own the appropriate equipment for gene technology laboratories, providing the students and teachers with pictures of the laboratory equipment and techniques will allow students to practice identifying the name and use of each piece of laboratory equipment. Similarly, a reminder of the experimental techniques utilized in the workshop may allow students to make a visual connection to the hands-on portion of the workshop. Figure 14 shows the technology and laboratory equipment page. Each photograph includes a brief description of the instrument and its use within the Gene Technology workshop.

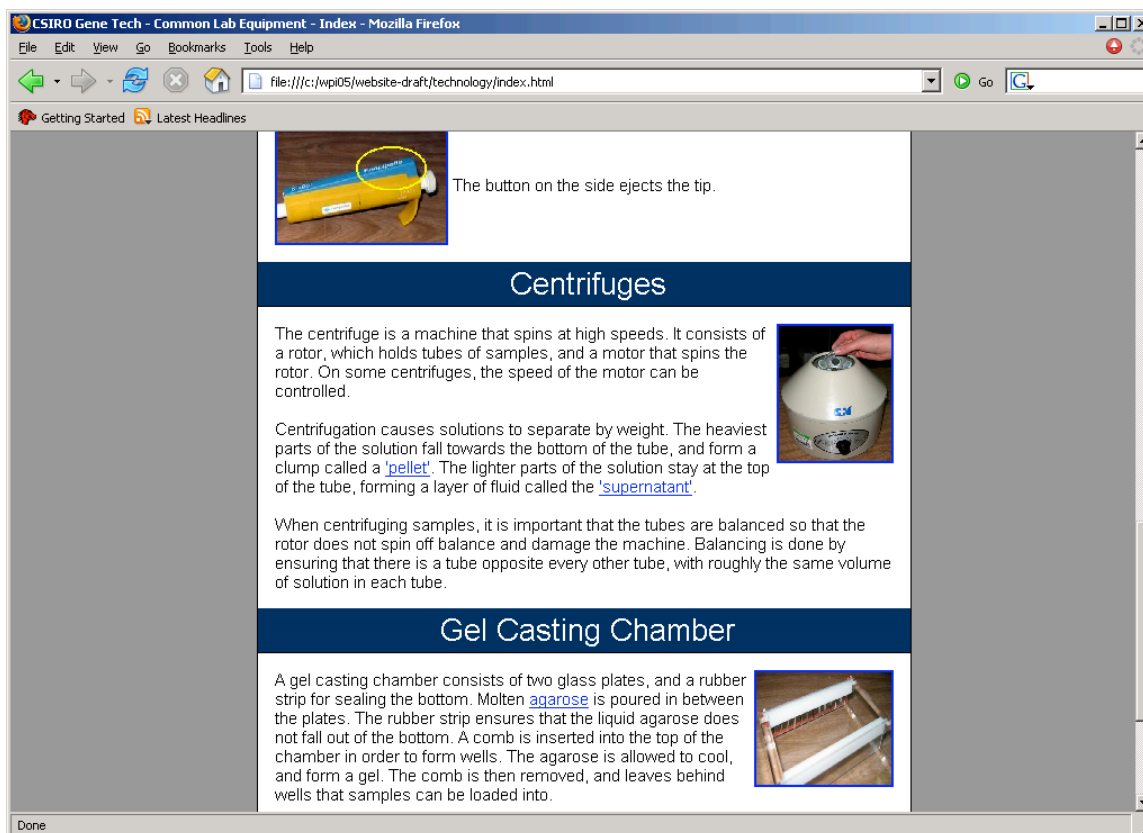


Figure 14 - Screen shot of the technology and laboratory equipment page.

5.3 Topic-specific Activities

The electronic unit contains activities that are designed for year 9 and 10 students. These activities range from ethical discussion questions to exercises that mimic laboratory experiments. Many of the activities were adapted from various published lessons plans available on the Internet. The published lesson plans provided a basis for our activities and inspired content ideas. Appendix K contains a full list and description of all the activities.

The activities are arranged by topic; however, the activities index also displays the goal, approximate time and brief description of each activity. According to education officers, this arrangement would allow teachers to scan the activities quickly, in order to find an activity of appropriate topic and length for their students. Figure 15 shows the arrangement of activities.

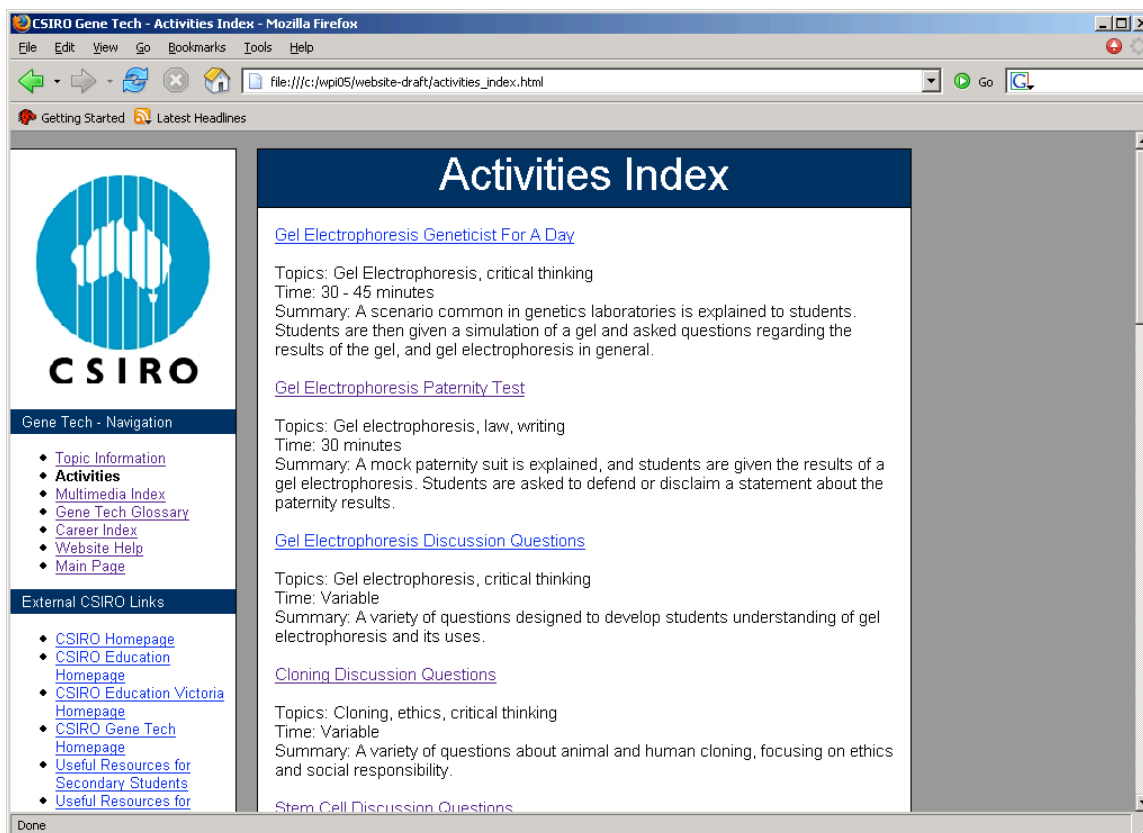


Figure 15 - Activities index screen shot.

Each activity was designed to address a particular aspect of its corresponding topic. For example, the gel electrophoresis activities provide students with practice reading a gel and gives students examples of gel electrophoresis use in the scientific community that are not discussed thoroughly in the workshop. The activity is similar to the gel electrophoresis completed in workshops, but employs a graphic representation of a final gel instead of a physical gel. Two scenarios are described: one mimics a plasmid insertion, the other describes a paternity test. Figure 16 shows the gel diagram for the paternity test activity. The scenarios, while different, are still applicable to the workshop themes according to education officers. Exposing students to different scenarios while still keeping the basic fundamentals in place may allow some students to understand gel electrophoresis better than they had during the workshop.

file:///c:/wp105/website-draft/gel_electrophoresis/activity2.html

Paternity Test

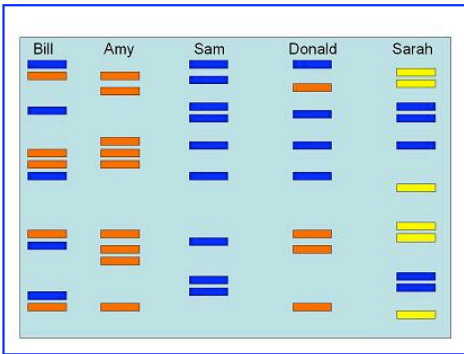
[Gel Electrophoresis](#) | [Multimedia](#) | [Activities](#)

[Gel Electrophoresis - Activity 2 - Paternity Test - Answers](#)

A wealthy man named Sam has recently died. He was married to a woman named Amy. They had two children, Bill and Donald. When Sam died, he left \$50 000 to each child.

A woman named Sarah called the family, and told them Sam was her father too. They decided to do a paternity test to determine if Sam is Sarah's father.

They compared the blood of the two children, as well as the blood of Sam, Amy, and Sarah. The results of the gel electrophoresis are below.



[Click for a bigger picture](#)

Using the results of the gel electrophoresis, argue either for or against Sarah's statement that she is Sam's daughter.

Figure 16 - Gel Electrophoresis Paternity Test activity.

The cloning, stem cells and genetically modified crops activities all involve various forms of ethical discussion. The education officers advised maintaining topic neutrality while describing these ethical questions. Ethical topics relate to the science domain of VELs, as they require understanding of controversial science topics found within current world events. The ethical questions also apply to the Thinking domain, found within the Interdisciplinary strand of the VELs. Debating ethical questions requires critical thinking skills.

The activities for restriction enzymes and polymerase chain reaction depict molecular-level reactions in a simple way. Education officers warned that students and teachers are typically unfamiliar with these topics, so the activity was simplified so that the basics of the principles could be understood. Both of these activities cater to visual learners because pictures or graphs illustrate abstract concepts. These activities also address the needs of kinesthetic learners because there is a hands-on component.

The answer sheets for teachers provide comprehensive answers which address broad issues on the topic as well as supplemental information the teacher might find helpful. Again, the style of these answer sheets is similar to those published in online

lesson plan formats. CSIRO education officers reviewed the answers, in order to ensure complete and accurate responses were provided for teachers.

6 Unit Assessment Results

Collectively, our final assessment results are positive with teachers expressing that they feel it to be a useful extension that they would utilize in their classes. However, we were able to conduct a limited amount of final testing of the completed Gene Technology electronic unit. Our final assessment consisted of surveying gene technology content experts, CSIRO Education Victoria staff, Victorian teachers who have observed the workshop recently, and educators external to Victoria and CSIRO's Gene Technology workshop. They analysed the usability of the unit as well as the quality of the contents of the unit; also expressing whether and how they would utilize the unit in class.

6.1 Website Usability

We obtained quantitative data from only 5 individuals, but all persons surveyed rated the layout of the website highly. The survey was based on a five point scale, with five being "very much" liking an aspect of the unit and 1 being "not at all" liking it. The results of final teacher interviews average out to: 4.4 for ease of navigation, 4.8 for the ability to locate desired information, 4.0 for website aesthetics, 4.4 for an easy to understand layout, 4.3 for ease of CD-ROM usage and 4.8 for operating correctly on the individual's computer. Oral interviews conducted with CSIRO Education Victoria staff yielded similar data. The staff found the design to be very user friendly and visually appealing.

The suggested improvements by teachers and CSIRO staff were minimal. One recommendation by a teacher would be to include a "Back" button on each page, which would be helpful in navigation. But due to technical limitations this is not possible. All web browsers have a "Back," button so this is not a critical feature. Further comments and recommendations dealt with small specific layout modifications.

6.2 Content Analysis

The teachers and tutors of various disciplines of science that we surveyed in our final assessment were asked to examine the multimedia and activities to determine whether they stand alone as useful materials. The purpose in doing so was to validate the learning unit as a tool useful to teachers who possess minimal gene technology knowledge. Teachers who do not have a strong background in gene technology and who do not observe the workshop are at a disadvantage when trying to teach more complicated gene technology concepts.

Those surveyed responded positively to questions concerning the contents of the website. However, Gel Electrophoresis and Cloning were the only sections heavily surveyed. (See Appendix O for compiled results) The background information was viewed as valuable for several reasons. Teachers without a strong gene technology

background found it helpful when forming their knowledge base. Regardless of background, teachers found that the background information section provided a good foundation for the activities.

Educators responded positively to the unit, saying that it was clear and interesting. The content was praised, with one respondent indicating that, "...the language is much more concise than many research papers published in recent years" (biotechnology tutor in USA, Survey Response, 2005.) The glossary section in particular ensured that the language used within the unit was easy to understand (high school physics teacher in USA, Survey Response, 2005). Teachers stated that the activities and multimedia would be used as a follow up to the CSIRO workshop or in place of the workshop. The activities and multimedia fit well within the workshop, according to teachers. They also felt that the various forms of media were used effectively within the unit, providing appropriate and interesting visuals. One teacher expressed that he makes use of visuals often so that the students are visual engaged and not simply looking at him talk. This is a common desire among teachers, to communicate information visually rather than orally.

General comments relating to the contents of the unit supported it as a valuable resource. According to one respondent, the unit allows teachers to expand upon the information covered within the workshop and provides a useful package that supports a genetics unit. There were some criticisms expressed by educators that would be worthwhile to address: ethical questions of cloning, ease of navigation within the website, and content layout. Teachers expressed a concern that ethical questions contained within the unit must be examined to ensure that the questions were impartial. As a representative unit of CSIRO, the unit should mirror its impartial science-oriented goals and opinions. Several teachers indicated that they experienced difficulty in easily navigating the web site. These same teachers indicated that fully sortable topic indices would be a valuable additional feature.

7 Conclusions and Recommendations

We have concluded that the Gene Technology electronic appeals to Victorian teachers. We feel that additional testing on other aspects of the unit will allow CSIRO Education Victoria to form definitive conclusions on the effectiveness of the unit. This chapter details the conclusions of the assessment as well as recommendations for future assessment.

7.1 Electronic Unit Validity

The Gene Technology unit is effective because we found that it appeals to Victorian teachers. The results gained from our assessment indicate that the Gene Technology electronic unit, as it stands currently, exemplifies what teachers desire in terms of electronically distributed materials. The department head for years 9 and 10 science at a major metropolitan high school stated that he would like to be first in line to receive a copy of the Gene Technology electronic unit once it is commercially available. This type of sentiment indicates that the Gene Technology electronic unit, at a conceptual level, is appealing to Victorian teachers.

Based on the results of our assessment, we can conclude that the content and activities are well-written and concise. In particular, the Gel Electrophoresis and Cloning sections were found by teachers to be informative and useful. Additionally, we can conclude that the multimedia in the unit is appealing to teachers. One teacher noted that the multimedia included within the unit was similar to that which he already employed in his classroom.

However, it needs to be noted that our assessment was limited by the fact that only a small number of educational professionals reviewed the Gene Technology electronic unit, as stated in Chapter 6. This group represents a broad view of the educators who might utilize the unit; however, more Victorian teachers need to be surveyed in order to conclusively determine the validity of the electronic unit with statistical significance. In addition, we feel that the five Victorian teachers surveyed do not represent an accurate cross-section of the types of teachers found within Victoria. The majority of teachers surveyed indicated that they already had a strong background in science and therefore certain sections of the unit (such as the background information section) were not as useful to them. Yet, there exists a large demographic within the population of teachers in Victoria that do not have a firm understanding of science and the Gene Technology electronic unit needs to be useful for that group as well.

Based on these results, we conclude that there exists a desire for the Gene Technology electronic unit, but additional testing will be necessary to determine how effective the unit is within classroom settings. A larger number of Victorian teachers

need to assess the unit in practice, in order to determine if it satisfies their needs as educators.

A limitation of our assessment was that only the Gel Electrophoresis and Cloning sections were heavily evaluated by teachers. Similar testing should be conducted on other sections of the unit. The activities included within the electronic unit were examined for age-appropriateness and clarity by CSIRO Education staff. However, the activities were never applied and tested by Victorian teachers. Therefore, a more in-depth evaluation of all contents within the unit (including the background information, multimedia, and activities) is desirable.

In addition, while teachers have indicated that the Gene Technology electronic unit appeals to them, it will be necessary to investigate how viable it is for those teachers to incorporate the information contained within the electronic unit into their classrooms. Specifically, the activities and multimedia within the unit need to be evaluated to determine their viability for use inside of the classroom.

7.2 Framework Effectiveness

Based on the website usability results described in the previous chapter, we can conclude the framework produces usable and effective interactive websites as exemplified by our implemented unit; however, we cannot conclude if the framework itself is useable. The HTML templates within the framework were never utilized by any CSIRO Education Victoria staff. CSIRO Education Victoria should analyse the framework in the future in order to determine how useable these templates and guidelines are.

We provided recommendations on how CSIRO Education Victoria can evaluate the usability of the framework. There are three approaches that can be used. The first is to have experts in website design and educational theory analyse the framework itself to determine how effectively it can communicate material and be implemented. The second approach is to attempt to implement the framework with various workshop topics and analyse the results. If all extensions developed are effective, then the framework used to create them is effective. If all extensions developed are not effective, then the framework is flawed. The third approach is to observe CSIRO Education staff in a controlled setting while they utilize the templates and record how effectively they are able to complete the task of creating an electronic unit.

Having experts in educational theory and website design analyse the framework as well as the implemented units would be invaluable to the assessment of the framework. The experts should test the framework for clear and topic independent templates, a visually appealing layout, effectiveness of communicating information in the format provided, and applicability to any topic. The framework, when implemented,

must communicate all necessary information for educators and students to teach and learn effectively.

7.3 Recommendations for Future Testing

It would be useful for CSIRO Education Victoria to conduct a usability study on the Gene Technology electronic unit that examines how teachers incorporate the contents of the unit into their classrooms. Ideally, this type of study would be conducted over long period of time, so that teachers would have an adequate amount of time to internalise the information within the unit and present it to students at their own pace. Also, in Victoria, subjects are taught by term and teachers are able to apply lessons learned within an earlier term to their teaching style in following terms. Conducting a study over the course of several terms would be an optimum way of assessing how teachers utilize the unit. In addition, we recommend that CSIRO Education Victoria utilize the framework design to implement units for several of its other workshops, in order to determine the usability of the framework design and conclusively determine whether the framework is applicable to all topics.

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Appendix A: The Commonwealth Scientific and Industrial Research Organisation

The Commonwealth Scientific and Industrial Research Organisation was founded in 1916 during World War I by the Australian government for the purpose of creating a nationally sponsored research agency. It was originally known as the Advisory Council of Science and Industry (ACSI), but in 1920 was renamed to the Commonwealth Institute of Science and Industry. The original goals of the Institute were to “...collect information about the state of scientific research in Australia; undertake research; review existing research; and collect and disseminate scientific information.” (CSIRO Organisation, 2005) However, these goals were not achieved due to a lack of funding. In 1920, Australia no longer possessed a war-time economy and did not see an immediate need for a governmental research organization. In 1926, a study by the British scientist Sir Frank Heath concluded that the structure of the Commonwealth Institute of Science and Industry was inefficient and disorganized, so the government created a new agency called the Council for Scientific and Industrial Research (CSIRO Organisation, 2005.)

The primary goals of the Council for Scientific and Industrial Research (CSIR) agency were to “...to carry out scientific research in connection with or in promotion of primary and secondary industries in Australia.” (CSIRO Organisation, 2005.) More specifically, the organization focused on several key areas of research, which were mostly agricultural in nature. The Council focused primarily on research regarding animal pests and diseases, plant pests and diseases, fuel problems, preservation of foodstuffs, and forest products (CSIRO Organisation, 2005.)

During World War II, the organisation again shifted back to a war-time stance, just as it did during World War I. The primary focus of the Organisation shifted from the agricultural industry to supporting the war effort, resulting in the establishment of additional laboratories and agencies that greatly contributed to the effectiveness of the Australian military. However, once the war was over, Australia again began to question the necessity of an organisation such as CSIR. There was a need for free and unrestrained scientific research, but there was also a need for the security of certain types and applications of research. Military research fell under this category and as a result, the Australian government passed the Science and Industry Research Act of 1949. CSIR was

then was forced to cease all of its military-related activity and renamed itself to the Commonwealth Scientific and Industrial Research Organization (interestingly enough, the organisation was again renamed in 1986 to change the spelling of 'Organization' to the current 'Organisation') (CSIRO Organisation, 2005.) From that point onward, the Organisation committed itself entirely to providing scientific and industrial research in all forms to the people and country of Australia as a whole. Its initial areas of interest included the environment, human nutrition, conservation, urban and rural planning, and water supplies. (CSIRO Organisation, 2005.)

Currently, CSIRO is Australia's largest government-sponsored research agency. It maintains fifty seven sites throughout Australia and has approximately 6500 full time employees. For the fiscal year 2003-2004, the most recent year for which data are available, CSIRO received A\$568 million in funding from the Australian government. During the same period, the Organisation itself generated A\$320 million from research, consulting, and other scientific work done for various other entities within the private sector of the Australian economy.

Appendix B: Web Site Cascading Style Sheet

This appendix explains the Cascading Style Sheet (CSS) used within the framework developed in this project. Cascading style sheets are an advanced feature of HTML that allows a web developer to manipulate how text and hypertext is displayed within a web browser. While the effects of text-manipulation can be accomplished simply by incorporating the corresponding styling information within each individual page, the true advantage of CSSs is that they can be linked to and utilized on many different web pages. Therefore, the usage of a CSS is conducive to creating a common look-and-feel across different hypertext documents. In addition, changes made within a CSS document will be reflected on every page that utilizes that CSS document. The effect of this fact is that if a web developer wishes to update portions of the layout, the developer only needs to update the single CSS document, rather than every page within the web site.

It is important to ensure that this file is accessible as in would need to be added to any new units implemented for different topics.

Contents of: stylesheet2.css

```
body {  
    background: #999999;  
    color: #000000;  
    text-align: center;  
    font-family: arial;  
    font-size: 11pt;  
}  
  
a:hover {  
    color: #FF0000;  
}  
  
img {  
  
}
```

```
#content {

    background: #ffffff;
    /* background-image: url('../draft150x150.jpg'); */
    color: #000000;
    border: 1px solid black;

    text-align: left;
    position: absolute;
    top: 15px;
    left: 219px;
    float: right;
    width: 580px;
    z-index: 2;
}
```

```
#left_link_bar {
    font-size: 10pt;
    text-align: left;
    border: 1px solid black;
    border-top: 1px solid black;
    border-left: none;
    width: 200px;
    float: left;
    background: white;
    position: absolute;
    /* background-image: url('../draft100x100.jpg'); */
    top: 15px;
    left: 0px;
}
```

```
#top_links {
    text-align: center;
    padding-bottom: 15px;
}
```

```

#footer {
    text-align: center;
    padding-top: 15px;
    padding-bottom: 15px;
    font-size: 9pt;
}

#one_column {
    text-align: center;

    width: 90%;
    border: 1px solid black;
    background: #FFFFFF;
}

.indent {
    padding-left: 15px;
}

.margins {
    padding-left: 15px;
    padding-right: 15px;
}

.heading {
    font-size: 30pt;
    background: #003366;
    color: #ffffff;
    border-bottom: 1px solid black;
    padding-bottom: 5px;
    padding-left: 10px;
    padding-right: 10px;
    margin-bottom: 15px;
    text-align: center;
}

```

```
.subheading {  
    font-size: 20pt;  
    border-bottom: 1px solid black;  
    margin-bottom: 15px;  
    padding: 3px;  
    padding-left: 10px;  
    margin-top: 15px;  
    background: #003366;  
    color: #ffffff;  
    text-align: center;  
}
```

```
.subheading_list {  
  
}
```

```
.db_heading {  
    background: #003366;  
    color: #ffffff;  
    padding: 3px;  
    padding-left: 10px;  
}
```

```
.list_heading {  
    font-size: 16pt;  
    color: #ffffff;  
    border-top: 1px solid black;  
    border-bottom: 1px solid black;  
    text-decoration: underline;  
    background: #003366;  
    padding: 3px;  
    padding-left: 10px;  
  
}
```

```
.disclaimer {
```

```
        font-size: 10pt;
    }

    .float_left {
        float: left;
    }

    .float_right {
        float: right;
    }

    .align_right {
        text-align: right;
    }

    .example {
        border: 1px solid black;
        margin-left: 35px;
        margin-top: 15px;
        margin-bottom: 15px;
        text-align: left;
        padding: 5px;
        font-size: 10pt;
        font-family: courier;
    }

    .answer {
        margin-left: 40px;
        margin-top: 15px;
        margin-bottom: 15px;
        font-size: 11px;
        border: 1px solid black;
        padding: 5px;
        text-align: left;
        font-family: courier;
    }
}
```

```

/* official CSIRO endorsed colors */

.darkblue {          /* main color */
    color: #003366;
}

.csiroblue {         /* main color */
    color: #0099CC;
}

.black {             /* main color */
    color: #000000;
}

.cool_grey {         /* main color */
    color: #999999;
}

.green {             /* secondary color */
    color: #99CC00;
}

.burnt_yellow {      /* secondary color */
    color: #996600;
}

.plum {              /* secondary color */
    color: #990066;
}

.burgundy {          /* secondary color */
    color: #660000;
}

.sample {
    font-size: 72pt;
    color: red;
}

```



```
    z-index: -1;  
    position: absolute;  
    left: 400px;  
    top: 200px;  
}
```

```
.sample2 {  
    font-size: 72pt;  
    color: red;  
    z-index: -1;  
    position: absolute;  
    left: 400px;  
    top: 400px;  
}
```

```
.sample3 {  
    font-size: 72pt;  
    color: red;  
    z-index: -1;  
    position: absolute;  
    left: 400px;  
    top: 600px;  
}
```

Appendix C: Directory Structure of the Framework

In order to function correctly, the framework must be situated within a specific directory structure. Each of the templates outlined in the following appendices utilize this structure. The main pages of the unit reside at the highest level. The pages at this level include the main “splash” page, the glossary, and the rest of the indices. In addition, the thumbnail images for the topic index pages are stored in this directory. Each topic within the unit resides in a subfolder whose name corresponds to the topic of the unit. For example, the “Gel Electrophoresis” information is contained within a subfolder called “gel_electrophoresis”. All information regarding the topic is contained within the subfolder for that topic, including the background information page, any multimedia, and the activities for that topic.

There are several other subfolders not associated with a particular topic. The stylesheets and official CSIRO logos are stored within a special second-level directory called “site”. The templates for each of the pages are contained within a special second-level directory called “templates”.

Figure 17 is a graphical depiction of the directory structure of our Gene Technology electronic unit.

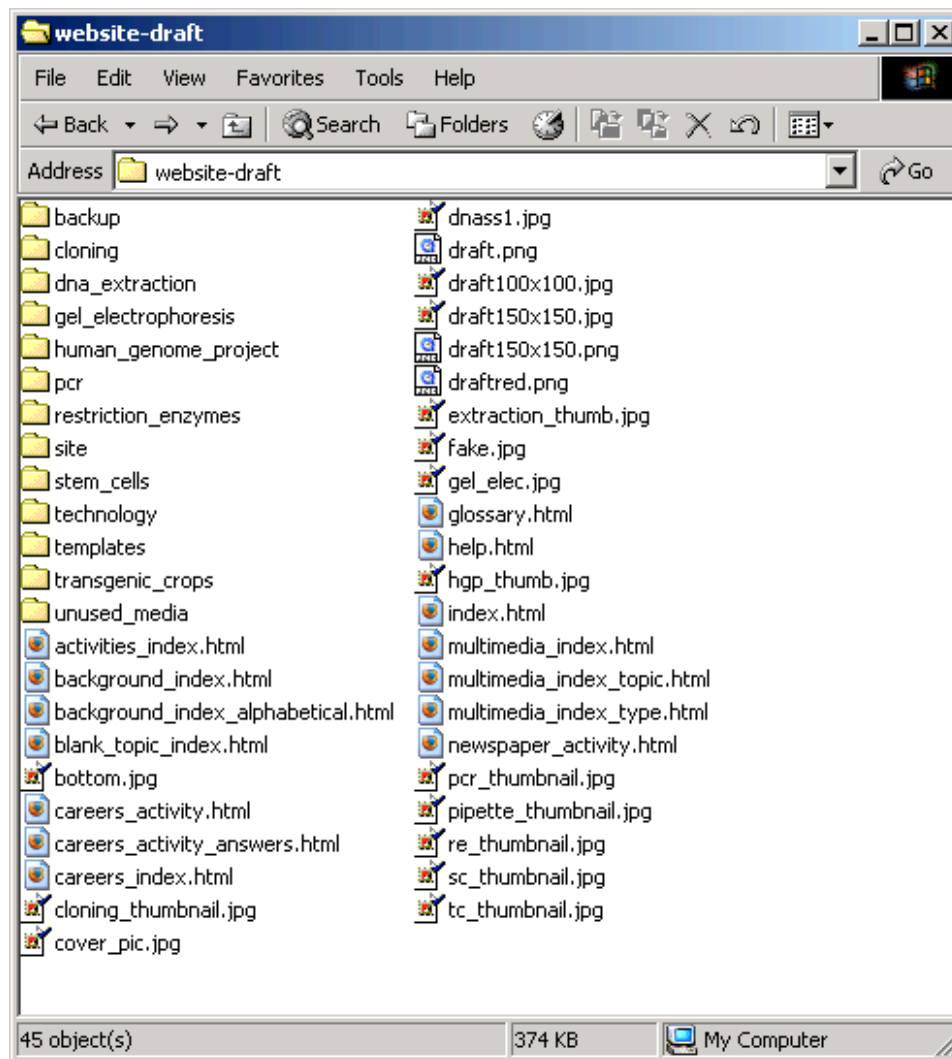


Figure 17 - Directory Structure of the Gene Technology electronic unit

Appendix D: Index Template

This template can be used to generate the various index pages that can be found within the electronic unit. This template applies to all of the main indices, including the Topic Index, the Multimedia Index, and the Activities Index. There can be multiple instances of this template implemented per electronic unit. Pages implemented using this template should reside in the main directory of the electronic unit. Please see Appendix C for information regarding the directory structure of electronic units.

The name of the file needs to correspond to what type of index the file is located in. For example, the “Topic Index” file must be saved as “background_index.html” and the Multimedia Index must be saved as “multimedia_index.html”. Following this logic, the activities index is called “activities_index.html” and the Careers Index is called “careers_index.html”.

To utilize this template, copy and paste the file located under the “Content of: index-page.html” subheading into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- **[**UNIT NAME**]**
 - o Replace this string with the name of the unit (i.e. Gene Tech)
- **[**topic**]**
 - o Replace this string with the name of the page (i.e. Topic Index)

Then, insert the coding to create the index content into the document at the location designated by:

```
<!-- index information inserted here -->
```

This template can be used for any page that resides at the main directory level, due to the way that the relative paths within each of the hyperlinks are written. In fact, this template should be used to generate the Glossary page as well, since the Glossary page resides within the main directory level.

Content of: index-page.html

```
<html>
<head>
<title>CSIRO [**UNIT NAME**] - [**topic**] </title>
<link rel="stylesheet" type="text/css" href="site/stylesheet2.css" />
</head>
<body>

<div id="content">
  <div class="heading">[**topic**]</div>
  <div class="margins">
    <!-- topic information inserted here -->
  </div>

  <div id="footer">
    All text and images copyright 2005 by CSIRO Education Victoria
    <br />
    <a href="http://www.csiro.au/melbcsirosec/" >CSIRO Education Victoria</a>
    <br />
  </div>
</div>

<div id="left_link_bar">
  
  <div class="db_heading">[**UNIT NAME**] - Navigation</div>
  <ul>
    <li><a href="background_index.html">Topic Information</a></li>
    <li><a href="activities_index.html">Activities</a></li>
    <li><a href="multimedia_index.html">Multimedia Index</a></li>
    <li><a href="glossary.html">[**UNIT NAME**] Glossary</a></li>
    <li><a href="careers_index.html" >Career Index</a></li>
    <li><a href="index.html">Main Page</a></li>
  </ul>

  <div class="db_heading">External CSIRO Links</div>
```

```
<ul>
  <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
  <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
  <li><a href="http://www.csiro.au/melbcsirosec/" target="_blank">CSIRO Education Victoria
Homepage</a></li>
  <li><a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students</a></li>
  <li><a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers</a></li>
</ul>
</div>
</body>
</html>
```

Appendix E: Background Information Page Template

This template can be used to generate the background information pages contained within a topic. There should be one instance of this page per topic contained in the electronic unit. This page should reside in the second-level directory of its parent topic as “index.html”. Please see Appendix C for information regarding the directory structure of electronic units.

To utilize this template, copy the index.html file into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- **[**UNIT NAME**]**
 - o Replace this string with the name of the unit (i.e. Gene Tech)
- **[**topic**]**
 - o Replace this string with the name of the topic of the article (i.e. Cloning)

After executing the find and replace, insert the information regarding the topic into the document at the area specified by:

<!-- topic information inserted here -->

Apply HTML formatting as needed (such as a
 to create a line break.)

Contents of: index.html

```
<html>
<head>
<title>CSIRO [[**UNIT NAME**]] - [[**topic**]] - Index</title>
<link rel="stylesheet" type="text/css" href="../site/stylesheet2.css" />
</head>
<body>
<div id="left_link_bar">
  
  <div class="db_heading">[[**UNIT NAME**]] - Navigation</div>
  <ul>
    <li><a href="../background_index.html">Topic Information</a></li>
    <li><a href="../activities_index.html">Activities</a></li>
    <li><a href="../multimedia_index.html">Multimedia Index</a></li>
    <li><a href="../glossary.html">[[**UNIT NAME**]] Glossary</a></li>
    <li><a href="../careers_index.html">Career Index</a></li>
```

```

        <li><a href="../index.html">Main Page</a></li><br />
    </ul>

    <div class="db_heading">External CSIRO Links</div>
    <ul>
        <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
        <li><a href="http://www.csiro.au/melbcsirosec/" target="_blank">CSIRO Education Victoria
Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers</a></li>
    </ul>
</div>

<div id="content">
<div class="heading">[**topic**]</div>
    <div id="top_links">
        <b>[**topic**]</b> | <a href="multimedia.html">Multimedia</a> | <a
href="activities.html">Activities</a>
    </div>

    <div class="margins">
        <!-- topic information inserted here -->
    </div>

    <div id="footer">
        All text and images copyright 2005 by CSIRO Education Victoria
        <br />
        <a href="http://www.csiro.au/melbcsirosec/">CSIRO Education Victoria</a>
        <br />
    </div>
</div>
</body>
</html>

```


Appendix F: Multimedia Page Template

This template can be used to generate pages that list the multimedia contained within a topic. There should be one instance of this page per topic contained within the electronic unit. This page should reside in the second-level directory of its parent topic as “multimedia.html”. Please see Appendix C for information regarding the directory structure of electronic units.

To utilize this template, copy and paste the multimedia.html file into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- **[**UNIT NAME**]**
 - Replace this string with the name of the unit (i.e. Gene Tech)
- **[**topic**]**
 - Replace this string with the name of the topic of the article (i.e. Cloning)

Then, insert hyperlinks to multimedia into the document at the location designated by:

<!--multimedia hyperlinks inserted here -->

Save the file as “multimedia.html” in the second-level directory belonging to the topic.

Contents of: multimedia.html

```
<html>
<head>
<title>CSIRO [**UNIT NAME**] - [**topic**] - Related Multimedia</title>
<link rel="stylesheet" type="text/css" href="../site/stylesheet2.css" />
</head>
<body>

<div id="content">
  <div class="heading">[**topic**] - Related Multimedia</div>
  <div id="top_links">
```

```

        <a href="index.html">[**topic**]</a> | <b>Multimedia</b> | <a
href="activities.html">Activities</a>
    </div>

```

```

<div class="margins">
    <!-- multimedia hyperlinks inserted here -->
    <a href="somemultimedia.jpg">First link to a piece of multimedia</a>
        <br /><br />
    <a href="someothermedia.swf">Another multimedia link</a>
</div>

```

```

<div id="footer">
    All text and images copyright 2005 by CSIRO Education Victoria
    <br />
    <a href="http://www.csiro.au/melbcsirosec/" >CSIRO Education Victoria</a>
    <br />
</div>
</div>

```

```

<div id="left_link_bar">
    
    <div class="db_heading">[**UNIT NAME**] - Navigation</div>
    <ul>
        <li><a href="../../background_index.html">Topic Information</a></li>
        <li><a href="../../activities_index.html">Activities</a></li>
        <li><a href="../../multimedia_index.html">Multimedia Index</a></li>
        <li><a href="../../glossary.html">[**UNIT NAME**] Glossary</a></li>
        <li><a href="../../careers_index.html" >Career Index</a></li>
        <li><a href="../../index.html">Main Page</a></li>
    </ul>

```

```

<div class="db_heading">External CSIRO Links</div>
    <ul>
        <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
    </ul>

```

CSIRO Education Victoria
Homepage

<a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students

<a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers

</div>

</body>

</html>

Appendix G: Activities Page Template

This template can be used to generate pages that list the activities contained within a topic. There should be one instance of this page per topic contained within the electronic unit. This page should reside in the second-level directory of its parent topic as “activities.html”. Please see Appendix C for information regarding the directory structure of electronic units.

To utilize this template, copy and paste the activities.html file into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- **[**UNIT NAME**]**
 - o Replace this string with the name of the unit (i.e. Gene Tech)
- **[**topic**]**
 - o Replace this string with the name of the topic of the article (i.e. Cloning)

Then, insert hyperlinks to each activity into the document at the location designated by:

`<!-- activities hyperlinks inserted here -->`

In this page, it is important to include a hyperlink to the answers or discussion guidelines for each activity. These links belong directly below the hyperlinks to the activities themselves. For example:

```
<a href="activity1.html">Link to activity 1</a>
<br />
<a href="answers1.html">Link to answers for activity 1</a>
<br /><br />
```

Save the file as “activities.html” in the second-level directory belonging to the topic.

Contents of: activites.html

```
<html>
<head>
```

```

<title>CSIRO [**UNIT NAME**] - [**topic**] - Activities</title>
<link rel="stylesheet" type="text/css" href="../site/stylesheet2.css" />
</head>
<body>

<div id="content">
  <div class="heading">[**topic**] - Activities</div>
  <div id="top_links">
    <a href="index.html">[**topic**]</a> | <a href="multimedia.html">Multimedia</a> |
  <b>Activities</b>
</div>

  <div class="margins">
    <!-- activities hyperlinks inserted here -->
    <a href="activity1.html">Link to activity 1</a>
    <br />
    <a href="answers1.html">Link to answers for activity 1</a>
    <br /><br />
    <a href="activity2.html">Link to activity 2</a>
    <br />
    <a href="answers2.html">Link to answers for activity 2</a>
    <br /><br />
  </div>

  <div id="footer">
    All text and images copyright 2005 by CSIRO Education Victoria
    <br />
    <a href="http://www.csiro.au/melbcsirosec/">CSIRO Education Victoria</a>
    <br />
  </div>
</div>

<div id="left_link_bar">
  
  <div class="db_heading">[**UNIT NAME**] - Navigation</div>
  <ul>
    <li><a href="../background_index.html">Topic Information</a></li>

```

```

        <li><a href="../activities_index.html">Activities</a></li>
        <li><a href="../multimedia_index.html">Multimedia Index</a></li>
        <li><a href="../glossary.html">[**UNIT NAME**] Glossary</a></li>
        <li><a href="../careers_index.html" >Career Index</a></li>
        <li><a href="../index.html">Main Page</a></li>
    </ul>

<div class="db_heading">External CSIRO Links</div>
    <ul>
        <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
        <li><a href="http://www.csiro.au/melbcsirosec/" target="_blank">CSIRO Education Victoria
Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers</a></li>
    </ul>
</div>
</body>
</html>

```

Appendix H: Individual Activity Page Template

This template can be used to generate pages that enumerate each activity contained within a topic. There can be multiple instances of this template implemented per topic, as each activity with each topic will use this template. Pages implemented using this template should reside in the second-level directory of its parent topic as “activity[**ACTIVITY NUMBER**].html”. Please see Appendix C for information regarding the directory structure of electronic units.

To utilize this template, copy and paste the activity.html file into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- [**UNIT NAME**]
 - o Replace this string with the name of the unit (i.e. Gene Tech)
- [**topic**]
 - o Replace this string with the name of the topic of the article (i.e. Cloning)
- [**experiment title**]
 - o Replace this string with the title of the activity (i.e. Paternity Test)
- [**activity number**]
 - o Replace this string with the number of the activity (starting at 1.)

Then, insert the content of the activity into the document at the location designated by:

<!-- activity information inserted here -->

Make sure to generate a corresponding answers page using the answers.html template. It is important to ensure that the number used to replace [**activities number**] is the same in the activity page and its corresponding answers page, or else the hyperlinks between the two pages will break.

Save the page as “activity [**activity number**].html” within the second-level directory corresponding to the topic.

Contents of: activity.html

<html>

<head>

```

<title>CSIRO [**UNIT NAME**] - [**topic**] - [**experiment title**]</title>
<link rel="stylesheet" type="text/css" href="../site/stylesheet2.css" />
</head>
<body>

<div id="content">
  <div class="heading">[**experiment title**]</div>
  <div id="top_links">
    <a href="index.html">[**topic**]</a> | <a href="multimedia.html">Multimedia</a> | <a
href="activities.html">Activities</a>
    <br /><br />
    <a href="answers[**activity number**].html">[**topic**] - Activity [**activity number**] -
[**experiment title**] - Answers</a>
  </div>

  <div class="margins">
    <!-- activity information inserted here -->
    Here's the activity!
  </div>

  <div id="footer">
    All text and images copyright 2005 by CSIRO Education Victoria
    <br />
    <a href="http://www.csiro.au/melbcsirosec/">CSIRO Education Victoria</a>
    <br />
  </div>
</div>

<div id="left_link_bar">
  
  <div class="db_heading">[**UNIT NAME**] - Navigation</div>
  <ul>
    <li><a href="../background_index.html">Topic Information</a></li><br />
    <li><a href="../activities_index.html">Activities</a></li><br />
    <li><a href="../multimedia_index.html">Multimedia Index</a></li><br />
    <li><a href="../glossary.html">[**UNIT NAME**] Glossary</a></li><br />
    <li><a href="../careers_index.html">Career Index</a></li><br />
  </ul>

```



```

        <li><a href="../index.html">Main Page</a></li><br />
    </ul>

<div class="db_heading">External CSIRO Links</div>
    <ul>
        <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
        <li><a href="http://www.csiro.au/melbcsirosec/" target="_blank">CSIRO Education Victoria
Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers</a></li>
    </ul>
</div>
</body>
</html>

```

Appendix I: Answers Page Template

This template can be used to generate answer pages that correspond to each activity contained within a topic. There can be multiple instances of this template implemented per topic and each instance of this template should correspond to one and only one activity page. Pages implemented using this template should reside in the second-level directory of its parent topic as “answers [**ACTIVITY NUMBER**].html”. Please see Appendix C for information regarding the directory structure of electronic units.

To utilize this template, copy and paste the answers.html file into a text editor and execute a “Find and Replace” on the following strings. This will insert the correct, topic-specific information into the resulting web page.

- [**UNIT NAME**]
 - o Replace this string with the name of the unit (i.e. Gene Tech)
- [**topic**]
 - o Replace this string with the name of the topic of the article (i.e. Cloning)
- [**experiment title**]
 - o Replace this string with the title of the activity (i.e. Paternity Test)
- [**activity number**]
 - o Replace this string with the number of the activity (starting at 1.)

Then, insert the answers into the document at the location designated by:

<!-- activity information inserted here -->

Make sure to generate a corresponding activity page using the activity.html template. It is important to ensure that the number used to replace [**activities number**] is the same in the activity page and its corresponding answers page, or else the hyperlinks between the two pages will break.

Save the page as “answers [**activity number**].html” within the second-level directory corresponding to the topic.

There is a section with the site’s CSS document that designates how an answer should look. It may be useful to utilize this specification within answer pages. It can be used as follows:

```
<div class="answers">Answers to questions here</div>
```

This “answers” class appears as a delineated text box on the answers page as shown in Figure 18.

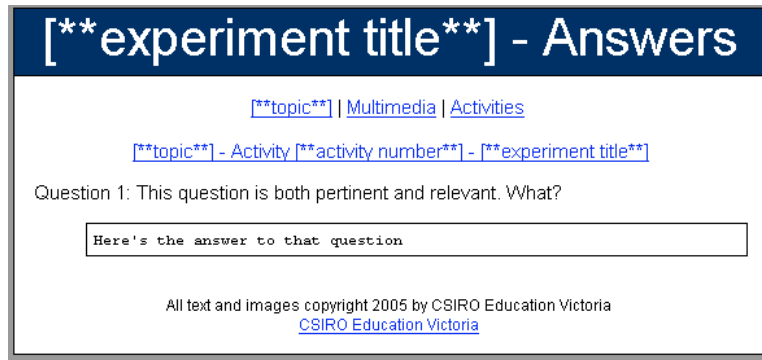


Figure 18 - Answer Class Delineated Text Box

Contents of: answers.html

```
<html>
<head>
<title>CSIRO [**UNIT NAME**] - [**topic**] - [**experiment title**] - Answers</title>
<link rel="stylesheet" type="text/css" href="../site/stylessheet2.css" />
</head>
<body>

<div id="content">
  <div class="heading">[**experiment title**] - Answers</div>
  <div id="top_links">
    <a href="index.html">[**topic**]</a> | <a href="multimedia.html">Multimedia</a> | <a
href="activities.html">Activities</a>
    <br /><br />
    <a href="activity[**activity number**].html">[**topic**] - Activity [**activity number**] -
[**experiment title**]</a>
  </div>

  <div class="margins">
    <!-- activity answers inserted here -->
```

```

        Put the answers here.
    </div>

    <div id="footer">
        All text and images copyright 2005 by CSIRO Education Victoria
    <br />
        <a href="http://www.csiro.au/melbcsirosec/" >CSIRO Education Victoria</a>
    <br />
    </div>
</div>

<div id="left_link_bar">
    
    <div class="db_heading">[**UNIT NAME**] - Navigation</div>
    <ul>
        <li><a href="../../background_index.html">Topic Information</a></li>
        <li><a href="../../activities_index.html">Activities</a></li>
        <li><a href="../../multimedia_index.html">Multimedia Index</a></li>
        <li><a href="../../glossary.html">[**UNIT NAME**] Glossary</a></li>
        <li><a href="../../careers_index.html" >Career Index</a></li>
        <li><a href="../../index.html">Main Page</a></li>
    </ul>
    <div class="db_heading">External CSIRO Links</div>
    <ul>
        <li><a href="http://www.csiro.au" target="_blank">CSIRO Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=educationIndex" target="_blank">CSIRO
Education Homepage</a></li>
        <li><a href="http://www.csiro.au/melbcsirosec/" target="_blank">CSIRO Education Victoria
Homepage</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Student_Assistance_Secondary"
target="_blank">Useful Resources for Secondary Students</a></li>
        <li><a href="http://www.csiro.au/index.asp?type=faq&id=Teacher_Assistance"
target="_blank">Useful Resources for Secondary Teachers</a></li>
    </ul>
</div>
</body>
</html>

```

Appendix J: Gene Technology Unit Content Overview

Gel Electrophoresis: The content of this topic includes a description of the materials and methods employed to perform a gel electrophoresis, as well as a discussion about applications of gel electrophoresis in forensic science and research science. The multimedia in this topic mimics the DNA movement in a gel and illustrates the examples of use discussed in the article. There are three activities included with this topic. One activity involves a paternity test. Students must analyze the sample gel provided, and then write a paragraph summarizing their results. The second activity illustrates gel electrophoresis use in an experimental laboratory setting and requires that students analyze a sample gel and answer a number of questions. The final activity is a list of discussion questions, designed to help students think critically about the process and use of gel electrophoresis.

DNA Extraction: The content of this topic includes a step-by-step discussion of a DNA extraction, supplemented with pictures. The activity for this topic is an outline of a simple DNA extraction using household items. The activity provides teachers and students with an opportunity to recreate DNA extraction without expensive materials.

Restriction Enzymes: The content of this topic includes a discussion on the mechanism and use of restriction enzymes. The activity for this topic has students mimic the action of a restriction enzyme on DNA, and then compares the differences between five restriction enzymes. This activity allows students to establish a firmer grasp on the mechanics of restriction enzymes.

Cloning: The content of this topic includes a simple description of cloning (with complementary Flash animation), a discussion of Tasmanian tiger cloning, and a discussion of serial nuclear transfer and Brandy the cow. The activities for this topic include a number of ethical questions in the area of human and animal cloning, as well as a handout covering single nuclear transfer and serial nuclear transfer.

Stem Cells: The content of this topic includes a discussion on the features and functions of both embryonic and adult stems cells, as well as the potential uses of stem cells in medicine. The activities for this topic include ethical questions and a handout on spinal cord regeneration.

Human Genome Project: The content of this topic includes a discussion on the research and goals of the Human Genome Project, as well as its applications to current genetic research. Also, a timeline of the major events in sequencing the human genome is provided. The activities for this section involve having students research the Human Genome Project, as well as a series of discussion questions.

Genetically Modified Crops: The content of this topic includes a discussion of how genetically modified crops are created and the benefits and drawbacks of using genetically modified crops. The activities include an ethical discussion, as well as an activity in which students must decide how (or if) to build a genetically modified crop.

Polymerase Chain Reaction: The content in this topic includes a discussion of the mechanics of polymerase chain reaction, as well as the uses in the modern genetic laboratory. The Flash animation provides a pictorial representation of polymerase chain reaction. The activity for PCR is must like that of restriction enzymes. Students work through an example of a PCR on paper in order to understand what occurs on a molecular level.

Careers in Gene Technology: The content of this topic includes a list of careers using gene technology and links to current CSIRO research. The activity for this topic challenges student to understand different gene technology-related careers and form links between the many different careers. This activity allows students to explore different professions related to gene technology and consider possible connections between each different career.

Common Laboratory Equipment: The content of this topic describes the function of the laboratory equipment used in the workshop, along with digital photographs of each piece of equipment.

Appendix K: Activity Descriptions

Gel Electrophoresis Geneticist For A Day

Topics: Gel Electrophoresis, critical thinking

Time: 30 - 45 minutes

Summary: A scenario common in genetics laboratories is explained to students. Students are then given a simulation of a gel and asked questions regarding the results of the gel and gel electrophoresis in general.

Gel Electrophoresis Paternity Test

Topics: Gel electrophoresis, law, writing

Time: 30 minutes

Summary: A mock paternity suit is explained and students are given the results of a gel electrophoresis. Students are asked to defend or disclaim a statement about the paternity results.

Gel Electrophoresis Discussion Questions

Topics: Gel electrophoresis, critical thinking

Time: Variable

Summary: A variety of questions designed to develop students' understanding of gel electrophoresis and its uses.

Cloning Discussion Questions

Topics: Cloning, ethics, critical thinking

Time: Variable

Summary: A variety of questions about animal and human cloning, focusing on ethics and social responsibility.

Stem Cell Discussion Questions

Topics: Stem cells, ethics, critical thinking

Time: Variable

Summary: A variety of questions concerning embryonic and adult stem cells and their use in research and medicine.

Restriction Enzyme Activity

Topics: Restriction enzymes, critical thinking

Time: 30 - 45 minutes

Summary: In groups, students will mimic the action of a number of different restriction enzymes using paper copies of DNA strands and scissors, compare results, and respond to questions about restriction enzymes.

Do-It-Yourself DNA Extraction

Topics: DNA Extraction, laboratory skills

Time: 1 hour

Summary: This is a DNA extraction that can be done with household items, either in the classroom or at home.

Build-A-Crop Activity

Topics: Genetically modified crops, plasmids, critical thinking

Time: 30 - 45 minutes

Summary: Students are given possible genetic traits that can be incorporated into a genetically modified crop. They are then provided with scenarios and must decide upon the best gene(s) to give to the crop. This activity can be done individually or in groups.

Genetically Modified Crops Discussion Questions

Topics: Genetically modified crops, ethics, critical thinking

Time: Variable

Summary: A variety of questions dealing with complications and ethics of genetically modified crops.

Human Genome Project Timeline Activity

Topics: Human Genome Project, research skills, writing

Time: 2 - 3 hours

Summary: A timeline of the HGP is provided and students are asked to research one event discussed in that timeline and communicate their findings.

Human Genome Project Discussion Questions

Topics: Human Genome Project, ethics, critical thinking

Time: Variable

Summary: A variety of questions about the Human Genome Project and its impact on genetics and science.

Polymerase Chain Reaction Activity

Topics: Polymerase Chain Reaction, understanding laboratory techniques

Time: 30 - 45 minutes

Summary: Students are walked through the process of PCR and required to answer questions about different steps and outcomes of PCR.

Newspaper Article Activity

Topics: Gene Technology, society

Time: Variable

Summary: Students are provided with a variety of different newspapers and asked to go through and find articles relating to gene technology, or genetics in general.

The articles are then discussed.

Careers Activity

Topics: Gene technology, science in society, critical thinking

Time: Variable

Summary: Students are provided with a list of careers and each student is assigned one career. The students must then find other professionals with whom they would cooperate.

Cloning Handout

Topics: Single and Serial nuclear transfer, cloning

Time: 15 - 20 minutes

Summary: A handout with a side-by-side comparison of single nuclear transfer and serial nuclear transfer.

Stem Cell Handout

Topics: Stem cells, spinal regeneration

Time: 15 - 20 minutes

Summary: A handout walking through spinal cord damage and possible stem cell regeneration. Serves as a good introduction to a discussion on the ethics of stem cells.

Appendix L: Sources Used in Content Generation of Gene Technology Unit

Gel Electrophoresis:

Alexander J. Ninfa, David P. Ballou. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc. Bethesda, Maryland. 1998.

Jeffery M. Cooper. The Cell: A Molecular Approach, Second Edition. ASM Press. Washington, DC. 2000.

DNA Extraction:

Alexander J. Ninfa, David P. Ballou. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc. Bethesda, Maryland. 1998.

Cloning:

Jeffery M. Cooper. The Cell: A Molecular Approach, Second Edition. ASM Press. Washington, DC. 2000.

<http://genetech.csiro.au>, 10 August 2004.

www.naturalworlds.org/thylacine/moretopics/cloning_1.htm, 2 April 2005.

www.biotechnology.gov.au, 03 June 2003.

<http://www.monashinstitute.org/emplibrary/SNT%20Fact%20Sheet.doc>.

<http://en.wikipedia.org/wiki/Epigenetics>, 12 April 2005.

Lab Equipment:

Alexander J. Ninfa, David P. Ballou. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc. Bethesda, Maryland. 1998.

Restriction Enzymes:

Jeffery M. Cooper. The Cell: A Molecular Approach, Second Edition. ASM Press. Washington, DC. 2000.

Stem Cells:

<http://stemcells.nih.gov/info/basics/>, 10 June 2004.

<http://www.biotechnology.gov.au>, 3 June 2003.

Genetically Modified Crops:

<http://scope.educ.washington.edu/gmfood/>, 2005.

<http://www.ncbe.reading.ac.uk/NCBE/GMFOOD/menu.html>, 2005.

<http://www.biotechnology.gov.au>, 3 June 2003.

Human Genome Project:

<http://www.genome.gov>, March 2005.

Polymerase Chain Reaction

www.dnalc.org, Cold Spring Harbor Laboratory, 2005.

Jeffery M. Cooper. The Cell: A Molecular Approach, Second Edition. ASM Press. Washington, DC. 2000.

Appendix M: CSIRO Staff Survey

We utilized this survey to gauge the effectiveness of activities and content within the completed electronic unit. This survey was distributed to CSIRO Education Victoria staff with a particular topic designated for review. Each staff member was asked to review a separate topic.

CSIRO Education – Gene Technology Education Officer Unit Survey

We appreciate you taking the time to help us improve the Gene Technology teacher unit. We welcome as many comments on the unit as you feel comfortable giving. Your feedback will help identify areas to be improved upon, as well as possible holes in the unit. Thank you in advance, we look forward to reading your comments.

The materials can be viewed by opening a web browser and navigating to:

<http://www.wpi.edu/~csirod05/latest/>

Please analyze this activity/discussion questions for us:

Comprehension:

1. Is it reasonable for teachers to understand and teach this?

2. Is it reasonable for year 10 students to understand this?

Content:

1. What do you think is the most valuable aspect of the activity?
2. What do you think is the least valuable aspect of the activity?

Level:

Is this aimed appropriately towards year 10 students? How can we improve it?

Focus:

1. Is the focus of this activity on an appropriate aspect of gene technology?
2. How could the focus be altered to better engage the students and communicate the material?

Phrasing:

Is the language clear and to the point? Where can it be improved?

Media:

1. Are there appropriate visual depictions? How can they be improved?

2. Are there other visual representations that would be helpful?

Other Questions:

1. Is there any activity or discussion on this topic of gene technology that you feel should be included, but isn't?

3. Do you have any comments on any of the other sections of the unit?

4. Do you have any other comments or suggestions that haven't been covered yet?

Appendix N: Teacher Survey

This survey was distributed to educators and used to evaluate single topics within the complete Gene Technology electronic unit.

CSIRO Education – Gene Technology Website Survey

We appreciate you taking the time to help us improve the Gene Technology teacher website. We welcome as many comments on the website as you feel comfortable giving. Your feedback will help identify areas to be improved upon, as well as possible holes in the website. Thank you in advance, we look forward to reading your comments.

The website can be found at: <http://www.wpi.edu/~csirod05/latest/>

Please choose any topic from the topic index and focus on the multimedia and activities for evaluation. Please indicate the topic you chose here:

Comprehension:

1. Is it reasonable for teachers to understand and teach this?
2. Is it reasonable for year 10 students to understand this?

Content:

1. What do you think is the most valuable aspect of the topic?
2. What do you think is the least valuable aspect of the topic?

Level:

Is this material aimed appropriately towards year 10 students? How can we improve it?

Focus:

1. Is the focus of this activity(s) on an appropriate aspect of gene technology?
2. How could the focus be altered to better engage the students and communicate the material?

Phrasing:

Is the language clear and to the point? Where can it be improved?

Media:

1. Are there appropriate visual depictions? How can they be improved?
2. Are there other visual representations that would be helpful?

Layout:

Please rate the following on a scale of 1 to 5. Circle one answer.

- | | | |
|--------------------|---------|-----------------------|
| 1 – No, not at all | 2 – No | 3 – Somewhat |
| | 4 – Yes | 5 – Yes, Very Much So |

- | | | | | | |
|---|---|---|---|---|---|
| 1. Was the website easy to navigate? | 1 | 2 | 3 | 4 | 5 |
| 2. Was it easy to find information on a specific topic? | 1 | 2 | 3 | 4 | 5 |
| 3. Was the layout aesthetically pleasing? | 1 | 2 | 3 | 4 | 5 |
| 4. Was the layout easy to understand? | 1 | 2 | 3 | 4 | 5 |
| 5. Was it easy to use the CD-ROM? | 1 | 2 | 3 | 4 | 5 |
| 6. Did the unit operate correctly on your computer? | 1 | 2 | 3 | 4 | 5 |

Other Questions:

1. Is there any activity or discussion on this topic of gene technology that you feel should be included, but isn't?

2. Do you have any comments on any of the other sections of the website?

3. Do you have any other comments or suggestions that haven't been covered yet?

4. Which aspects of this website would you use in your classroom?

About You:

Subject(s) Taught: _____

Class Year(s) Taught: _____

On average, how well do you rate your knowledge of gene technology?

Poor Fair Good Very Good Excellent

Thank you for completing this survey. Please e-mail your comments to csiro-d05@wpi.edu or fax to 9252 6256.

Appendix O: Compiled Survey Results

Survey results used a scale of 1 to 5 with 1 being “not at all” and 5 being “very much so”.

Was the website easy to navigate? 4.4

Was it easy to find information on a specific topic? 4.8,

Was the layout aesthetically pleasing? 4.0,

Was the layout easy to understand? 4.4,

Was it easy to use the CD-ROM? 4.3,

Did the website operate correctly on your computer? 4.8

Cloning: How useful is this info?

4.5

Discussion questions appropriate:

Yes, especially with the glossary of terms

Show animations to students:

Yes, anything would be more exciting than looking at me

In the context of the topics many of the animations need the context of the topic to understand their significance

Even though the animations are basic in design the content is good

Gel electrophoresis: how useful is this information? 4.6

Very clear and concise

Is anything discussed unclear?

No, not when combined with the actual visit from CSIRO

In reading the ‘Geneticist for a Day’ exercise, the problem posed describes the sequence of the gene; in utilizing a gel to determine if an insert has been added to a vector, a researcher would look for a band size or weight, since the sequence cannot be directly observed. The transition between talking about probes and talking about size is abrupt.

Would you use the gel electrophoresis activities in your classroom:

In the absence of a visit from CSIRO, yes

Yes, although not the geneticist for a day

Yes, as a follow up after the CSIRO visit

Comments on other topics?

Good general info that shows the applications of gene technology

More detail on how stem cells differ at the DNA level that makes them able to differentiate as they do

Any area that should be covered that is not?

Legal situation on cloning or stem cells

Any other activities that you think should be included?

Just more.

Do you feel that this website is a useful extension to CSIRO's Gene Technology workshop?

Yes, covers more detail at more advanced level that many of our kids would appreciate. The language is readable for senior students although year 10s would struggle

Yes more info which follows on great research point for students – clear (check mark)

Yes it allows teachers to expand on the info covered as well as providing useful teaching packages to supplement a genetics unit

Develop more diagrams in text

More interactive activities....although they have made a great start

The language is much more concise than many research papers published in recent years